NOTES ON THE GEOLOGY OF THE CONTINENT OF AFRICA.

WITH AN INTRODUCTION AND BIBLIOGRAPHY.

COMPILED IN THE DEPARTMENT OF THE GENERAL STAFF, WAR OFFICE,

BY

ALEXANDER KNOX, B.A., *Map Curator.*

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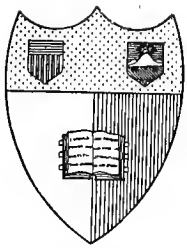

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PREFACE.

THE chief value of these Notes lies in the large number of references to works where fuller information may be obtained, it being only possible, within the limits of such a book as this, to give a general and brief outline of what may there be found.

The Bibliography has been divided geographically into six sections—General; North-West; North-East; Equatorial West; Equatorial East, and South—in order to facilitate reference.

J. M. GRIERSON, *Major-General,*
Director of Military Operations.

WAR OFFICE, 1904.

CONTENTS.

Reference Map and Plate of Sections in pocket.

ABBREVIATIONS.

A.F.	Bulletin du Comité de l'Afrique française. Paris.
A.G.	Annales de Géographie. Paris.
Ann.	Annales.
Ball	Kharga Oasis. Cairo. 1900.
Barré	La géographie militaire et les nouvelles méthodes géographiques. Paris. 1899.
Barth	Reisen und Entdeckungen in Nord- und Central-Afrika. Gotha. 1857.
Barth (a)	The English edition of the above.
Baumann	Durch Massai-land zur Nilquelle. Berlin. 1894.
B.C.	Belgique Coloniale. Bruxelles.
Beadnell (1)	Dakhla Oasis. Cairo. 1901.
Beadnell (2)	Farafra Oasis. Cairo. 1901.
Bruce	Travels to discover the source of the Nile. 5 vols. 1790.
Brunet	Dahomey et Dépendences. Paris. 1900.
B.S.G.	Bulletin de la Société de Géographie. Paris.
B.S.G.I.	Bollettino della Società geografica italiana. Rome.
B.S.K.....	Bulletin de la Société Khédiviale de Géographie. Cairo.
C. 6998, &c.	Parliamentary Paper No. 6998, &c.
Cameron	Across Africa. 2 vols. 1877.
Cd. 1769, &c.	Parliamentary Paper (New Series) 1769, &c.
Choisy....	Documents relatifs à la mission dirigée au Sud de l'Algérie. Paris. 1890.
Clapperton (1)	Narrative of Travels and Discoveries in Northern and Central Africa. London. 1826.
Clapperton (2)	Journal of a Second Expedition into the Interior of Africa. London 1826.
Cornet....	Congrès national d'hygiène et de climatologie médicale de la Belgique et du Congo. Seconde partie. La constitution du Sol. Bruxelles. 1898.
De Lapparent	Traité de Géologie. Paris. 1893.
D.K.	Deutches Kolonialblatt. Berlin.
D.K.Z.	Deutsche Kolonialzeitung. Berlin.
Dreyfus	Six mois dans l'Attié. Paris. 1900.
Gibson	The Geology of Africa in relation to its mineral wealth. Newcastle-on-Tyne. 1896.
G.J.	The Geographical Journal. London.
J.A.S.	Journal of the African Society. London.
J.R.G.S.	Journal of the Royal Geographical Society. London.
Junker	Reisen in Africa. 3 vols. Vienna. 1891.
Junker (a)	The English edition of the above by Keane.
Lenz	Timbuktu. Leipzig. 1884.
Livingstone (1)	Livingstone's last Journals. London. 1874.
Livingstone (2)	Narrative of an expedition to the Zambesi and its tributaries and of the discovery of Lakes Shirwa and Nyasa. London. 1865.
Livingstone (3)	Missionary travels and researches in South Africa. London. 1857.
L.P.C....	La politique coloniale. Paris.

Marno....	Reisen in der Egyptischen Aquatorial-Provinz und in Kordofan. Vienna. 1878.
M.D.S.	Mitteilungen aus den deutschen Schutzgebieten. Berlin.
M.G.	Mouvement Geographique. Bruxelles.
M.J.	Mining Journal.
Monteil	De Saint-Louis à Tripoli par de lac Tchad. Paris. 1895.
M.P.G.	Mitteilungen, Petermann's, Gotha.
Nachtigal	Sahara und Sudan. Berlin. 1879–89.
Peters....	Das Deutsch Ost-Afrikanischen Schutzgebiet. Leipzig. 1895.
P.G.A.....	Proceedings of the Geologists Association. London.
P.R. Col. Inst.	Proceedings of the Royal Colonial Institute. London.
P.R.G.S.	Proceedings of the Royal Geographical Society. London.
Q.D.	Questions diplomatiques et coloniales. Paris.
Qr. J.	The Quarterly Journal of the Geological Society. London.
Quiroga	Observaciones hechas en al Sahara occid. Annales de la Soc. espan. de Hist. Nat. 1889.
Rambaud	Une mission au Sénégal. Paris. 1900.
Ramsay	Physical Geology and Geography of Great Britain. 1872.
R.F.E.C.	Revue française de l'étranger et des colonies. Paris.
R.G.	Revue de Géographie. Paris.
R.G.S.	Royal Geographical Society.
Rohlfs....	Kufra. Leipzig. 1881.
Rohlfs (a)	Meine Mission nach Abessinien. Leipzig. 1883.
Rolland	Géologie du Sahara algérien et aperçu géologique sur le Sahara. Paris. 1890.
Sacchi	L'Omo. Vannutelli and Citerni. Milan. 1899. (Chapter on Geology.)
Schirmer	Le Sahara. Paris. 1893.
S.G.	Société de Géographie (Compte Rendu). Paris.
S.G.M.	Scottish Geographical Magazine. Edinburgh.
Stanley (1)	Through the Dark Continent. 2 vols. London. 1878.
Stanley (2)	In Darkest Africa. 2 vols. London. 1890.
Stuhlmann	Mit Emin Pascha ins Herz von Afrika. Berlin. 1894.
T.	"The Times."
Thomson	To the Central African Lakes and back. 2 vols. 1881.
T.M.	Tour du Monde. Paris.
V.G.E.	Verdhandlungen der Gesellschaft für Erdkunde. (Supplement to Z.G.E.)
Vogdes	Department of Applied Sciences of the U.S. Artillery School : Geology. Fort Monroe, Virginia. 1884.
von Reichenbach	Die Geologie der Deutschen Schutzgebiete in Africa. Munich. 1896.
Wauters	L'Etat Independant du Congo. Brussels. 1899.
Z.G.E.	Zeitschrift der Gesellschaft für Erdkunde. Berlin.
Zittel	Über den geologischen Bau der libyschen Wuste. Munich. 1880.

The remaining abbreviations need no explanation.

NOTES ON THE GEOLOGY OF THE CONTINENT OF AFRICA.

INTRODUCTION.

I.—*Military Geology.*

1. It may appear to be a work of supererogation to insist once more on the very important bearing of the science of geology on the sister science of geography. It is universally acknowledged, though generally in a half-hearted manner, that the former is the basis upon which the latter is built, but in practice this dependence is not so strongly insisted upon as would seem to be desirable, yet to almost every fundamental geographical question geology supplies the unerring reply, and as these notes are intended mainly for the use of military men, a few words on some of the practical relations may not be out of place.

2. Geography has lately been concisely defined as "the science which deals with the forms of relief of the earth's crust, and with the influences which these forms exercise on the distribution of all other phenomena," and few will be found to traverse the proposition of the propounder of this definition that the "glory of geography as a science, the fascination of geography as a study, and the value of geography in practical affairs, are all due to the recognition of this unifying influence of surface relief in controlling, though in the higher developments rather by suggestion than dictation, the incidence of every mobile distribution on the earth's surface." Mill, G.J., xviii, 1901, p. 410.

3. Now relief is governed mainly by geological considerations. The exterior form of the surface of the earth depends on three elements, namely, the nature of the materials, their architectural disposition and the sculpture super-imposed on this architecture by external agents, the third being partially dependent on both the first and second, and thus the consideration of the relief cannot be separated from the geological history, the petrological constitution and the atmospheric and biological influences which help to modify the form of the terrain. For instance, to take a practical example, if we have a region of medium elevation composed for the most part of beds of sandstone, shale and limestone, dipping in some determinate direction, any one with a fair knowledge of geology will have no difficulty in indicating what the dominant character of the surface will prove to be. If he knows the geological age of the strata and has reason to believe that the Barré, p. 15. S.G.M., 1900, p. 139.

land has been for a long period subject to erosion and denudation, he will expect it to be traversed by parallel ridges and escarpments with intervening hollows, as in some parts of the Atlas region. So, again, should the beds be horizontal, as in portions of the Upper Karoo formation and in the Sahara, the valleys will probably be trench-like and the intervening heights will form either pyramidal or tabular hills and mountains. Once more, should the rocks be highly folded and contorted, and traversed by irregular masses of igneous origin, such complicated structures are sure to give rise to a highly diversified configuration, as in the Zwarteberg and Zuurberg of the Cape Colony.

4. The water system of a region depends on the geological conformation of the surface and the rain which falls on it, or, as the mathematicians say, hydrography is a function of two variables, relief and rainfall. But these two variables are not independent. The relief may and does exert a very powerful influence on the rainfall, the lofty mountain masses acting as condensers, bringing down the rain in their immediate neighbourhood and thereby depriving localities to leeward of the moisture, which would otherwise have reached them. The rainfall, again, has been one of the agents in the erosion and wearing away of the accidents of relief, and in reducing mountains to what are known as peneplains. This action, however, though incessantly carried on, is, so far as existing circumstances for any limited period are concerned, negligible; and at any given time the relief may be said to be independent of the rainfall, which, on the other hand, is always to a large extent dependent on the relief. Thus the Atlas range exerts a very powerful influence on the rainfall, not only of Marocco and Algeria, but in regions to the south and south-east. The volcanic masses of Kilimanjaro and Kenia send down countless streams to the plains below, while on the other hand the mountains of the North Guinea coast have been reduced, in what is now the forest zone, to a peneplain.

Barré, p. 36.

5. The action of rivers on the lands through which they flow is of a two-fold nature, mechanical and chemical, and though the former is, in the case of most rocks, the more important of the two, and its results certainly more evident, yet the latter is more powerful than is usually supposed. Some idea of the magnitude of the results of this chemical and invisible action may be gathered from the fact, deduced from the analysis of water taken from the Thames at Teddington, that nearly 400,000 tons of matter are annually carried in solution by that river to the sea. The result of this chemical action depends on the petrological formation of the basin of the river. The mechanical action is three-fold, and consists of erosion, transport and deposition, which are to a certain extent interdependent, the volume of the deposit corresponding with the eroded matter which gave it birth. In the upper course of a stream erosion is continually going on, and the bed is continually being deepened. Even in the middle and lower courses the wearing action of the detritus transported is experienced in times of flood in the greater number of streams. This action of the detritus is called by American geologists abrasion. For a

Ramsay, p. 259.

S.G.M., 1899, p. 301, *sq.*

Barré, p. 42.

Vogdes, p. 12.

given slope, the force of the action depends on the nature of the materials dragged over the bed, that is to say, the degree of hardness of the rocks determines the intensity of the erosion, so that here again the geological formation is of the first importance. This erosive action is most strikingly seen in mountain streams, dragging a quantity of loose rocky material.

6. Again, the amount of water absorbed by the soil, as a river system finds its way to the sea or some lake or fails in the attempt, varies according to the material of which the basin consists, that is, on the lithological character, arenaceous, calcareous and argillaceous beds affording very different results. Thus the geological constitution of the area becomes an important element in the discharge of a river. Further, on the system of architecture or orography depends the direction taken by the water after it has fallen on the surface, and, therefore, the direction of the river courses and the division into basins. The succession of the strata, too, upheaved at an angle will exert a very powerful influence on the hydrographic system. Some strata will be harder than others and the softer will generally give way first, forming the beds of water courses, which will vary in character according as the structure is tabular or folded. Again, the conditions most favourable to the formation of waterfalls and rapids, which constitute so striking a feature in African rivers, are the difference in the degree of hardness of the rocks, the transition from one geological formation to another, and faults, and dykes running across the bed. A very interesting instance of the effect of the geological structure on the canalisation of a stream is afforded by our own Thames, where wittingly or unwittingly the authorities have placed a lock at every change of formation.

Barré, p. 46.

7. In the development of Africa there is, perhaps, no more important consideration than that of communications, and it would be difficult to exaggerate their importance from a military point of view. And if the natural communications, as supplied by the waterways, are limited and controlled by the geological formations, how much more are the artificial highways dependent in every particular on the same governing influences. Suppose, for instance, that the orographical structure favours a general plan for a road or a railway, then the selection of the actual route will depend on the succession of the strata. To take an example which lies close at hand and can, therefore, be easily verified: At the foot of the chalk escarpment of the North Downs is a narrow outcrop of the upper greensand, in some places scarcely 100 yards wide, and this in turn is followed by a broader outcrop of gault. A glance at the geological map will show how astutely the engineer has clung unswervingly to the narrow band of greensand as his railway comes from the west and sweeps past Dorking, until he is compelled to make for Reigate, when he rushes slantingly across the gault.

Geol. Survey, 1-inch map, sheet No. 8, O.S.

8. The actual details of construction, too, and of maintenance of both roads and railways are dependent on the lithological constitution of the terrain. The main requisite for keeping a road or the platform of a railroad in sound and good condition, being

a perfect system of drainage, a different method of construction will be employed according to the material—one for hard rock and clay, another for more permeable material and so on. The supply of ballast for a railway and of metal for repairing a road are also immediately dependent on the geological formation of the districts through which they pass.

9. The following, taken from the report on the administration of Rhodesia 1898–1900, seem particularly to the point:—"The road from Karonga to Fort Hill is impassable for wheeled traffic." "For the first 35 miles from Gwelo the Bulawayo–Salisbury road has been removed to the waterparting" (p. 264). "The deviation on the road over Christmas Pass will be completed shortly. The route laid out by X. was not adopted, but a different one taken by Y., with the result that the road has a solid foundation" (p. 290). ". . The road leading from Victoria to the Selukwe mines being particularly in better condition. It is difficult to keep this road in really good trim, owing to the absence in the neighbourhood of suitable material for repairs; the Enkeldoorn road, running as it does over harder and higher ground, is comparatively easy to keep up" (p. 293).

10. The Nile makes a great bend as it turns from a south-east —north-west to a north-east—south-west direction south of the 20th parallel. The Ubangi, too, makes a huge curve as it turns from an east to west to a north to south direction in the neighbourhood of the 5th parallel, but for vastly different reasons, and geology gives us the clue. The Stevenson road, which is now of mature age, remains in fairly good condition; the railway near Mombasa needs constant repair, and geology tells us why. The Rangatan is a fruitful grazing land; the Nyika a desolate waste, and geology again supplies the reason. The underground water supply depends entirely on the stratigraphical arrangement of the beds and the materials of which they are composed, and the practised eye of the geologist can with ease detect the localities where water will probably be found, and can with equal facility select suitable positions for temporary or permanent camps, choosing spots which will be free from marsh in the rainy season, but at the same time afford an ample water supply.

Holdich, G.J., No. V, 1899, p. 467.

11. In conclusion, one of the highest authorities on the subject, in a paper on boundary delimitation, expresses himself thus: "The widest geographical knowledge will prove the best safeguard against misunderstanding . . . By geographical knowledge I do not mean simply that knowledge of the earth's surface which we gain by surveying it. I mean also a knowledge of those ordinary laws of Nature which decide the configuration of mountains and the flow of rivers, where certain influences must inevitably lead to certain conditions."

II.—*Our Sources of Information—Age of Africa.*

12. In order that a precise geological survey of any area may be undertaken, the first requisite is a pre-existent topographical

survey, and as we are very far from possessing anything of the kind for Africa, the former survey is out of the question, unless, indeed, the two be carried on simultaneously. Our knowledge, in fact, of the geology of Africa is in its first infancy. A regular geological survey is being carried on in the north of Algeria, the only portion of the continent of which there is a precise topographical map; a systematic survey has been undertaken for Lower Egypt, and a commission has been at work in the extreme south of the continent, while the first report of the geological survey of Natal and Zululand has lately appeared. With these exceptions our knowledge chiefly depends on more or less complete studies of isolated areas by various travellers with generalisations based on them; here and there a comparatively superficial reconnaissance survey, and scattered notes made by men with very varying scientific qualifications from the professional geologist to the lay hunter. But limited and disconnected as our information is, it is of the very greatest interest and value.

13. Such information, as is at our disposal, points to the fact, as Pomel has shown, that Africa, if not the oldest, is at least one of the oldest of the continents. The geological continent consists of two parts, namely, the geographical continent, that is the dry land portion which is depicted on the maps, and the submarine foundation or platform on which it stands, and there is a striking similarity in shape between the two, the projections and indentations, such as exist, and the long even stretches of coast being carried far away down into the depths of the ocean, so that it is found that the 1,000 fathom line traces out a curve which bears a very close resemblance to the outline or contour representing the water-mark of what I have called the geographical continent. This would appear, when taken in connection with other facts which will be dealt with later, to indicate a settled state, a prolonged existence without any such violent disturbance or recent great upheaval or subsidence as would tend to disturb the curve of sea-level. It is true, as we shall presently see, that there have been disturbances, especially in the east, but these have not been of such magnitude as to upset the general outline, but have rather been confined to a comparatively narrow meridional belt. Another fact which points to the extreme age of Africa is the lack (if we except the Congo mouth, &c.) of those irregularities in the coast line, those indentations and projections which form so marked a feature in the outline of Europe and Asia, the only real gulf being the southerly incision between the highlands of Barka and the Atlas, known as the Gulfs of Sidra and Gabes, the Gulf of Guinea being rather a curve in the coast-line than a gulf. It is argued from this regularity of outline that the gulfs and the bays of past ages must have been gradually filled up by the action of running water, the rivers bearing down their "ceaseless burden" of detritus, and filling up these indentations with the débris of the highlands of the interior. A glance at a map showing the mouth of the Mississippi will at once make clear the process by which such results are brought about.

Times Atlas, 1900, sheet 4.

14. Both these facts testify to the great age of the continent,

and, if enquiry be made into more minute particulars, ample corroboration will be forthcoming. The greater part of the surface of Africa is composed of the older rocks, limestones, and sandstones and other formations of the Palæozoic age with granites, gneisses and crystalline schists. The precise position in the series of many of the strata is undetermined, for Africa is no paradise for the palæontologist, the fossil-hunter finds his treasures few and far between, and, though lithological considerations afford some light, it will require further study to locate the position of, for instance, the Table Mountain sandstone and the Witwatersrand beds, though they are both certainly of Palæozoic age. During the Devonian period large parts of the continent were under water in both the north and south. As the older portions of the continent gradually emerged from the waters, there were left great inland seas and lakes in the north, north-west, centre and south, studded, especially in the central portion, by islands. One of the first of these inland seas to disappear was the Karoo district, which, being of Permian origin, closes the Palæozoic era.

De Lapparent, pp. 815–818.

15. The transition period—if the expression may be used—between the Palæozoic and Mesozoic ages, as well as the earliest portion of the latter, are represented by the great Congo basin, the strata occupying this area being classed as Permo-Triassic and Triassic. During this early Mesozoic period, therefore, the Congo area must still have been a lake, and so, too, great areas in the north must have been still under water, for here there are wide expanses of Jurassic and Cretaceous rocks, notably the Nubian sandstone and the Turonian and Senonian of Tripoli, &c. By the latter end of the Mesozoic period the west and west-central regions appear to have assumed very much the configuration which they now present, and the larger part of the continent, with the exception of the Mediterranean slopes and portions of the west coast lying north and south of the Senegal, must have been dry land and had its axis running close along the eastern side, from south-west to north-east, in what is now known as the coast range, which extended, at that period, from the Drakensberg of Natal and the Hoogeveld of the Transvaal to the Shoho Mountains of Eritrea and probably even to the Ababd Mountains of Egypt.

Gregory, G.J., iv, 1894, p. 239.

16. During the Mesozoic period—probably the later part—the eastern side of the continent was subjected to violent convulsion; volcanic disturbance rent the whole surface throughout the entire extent of a great meridional belt, upheaving what now constitutes the main axis. Subsequently there appear to have been two, if not three, periods of volcanic activity. In fact a line of weakness seems to have existed in the earth's crust, and resulted in a series of volcanic upheavals, subsidences and outpourings, from time to time, along this line of least resistance, extending from Lebanon in the north, through Abyssinia and Aden, past Lake Rudolf, and continued through the volcanic range whose principal peaks are Kenia and Kilimanjaro, down southwards, crossing the Zambesi at the falls, and traceable as far as Kuruman in Bechuanaland and Prieska. Such are the facts, but how this state of things was

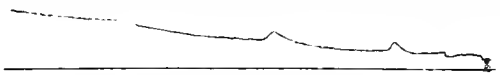
Koettlitz, G.J., xv, 1900, p. 364.

Livingstone (1), ii, p. 215.

developed, in accordance with which of the various theories the continent itself and the primitive axis were brought into existence, does not lie within the scope of these notes, whether by Kelvin's nebulous segregations, or Darwin's primitive wrinkling, or the double folds of Lapworth and Lubbock, or the faulted crust-blocks of Suess.

III.—*Eastern Africa.*

17. It appears from what has been said that the eastern and western sides of the continent have arrived at their present configuration by widely different developments, or rather, that the eastern development was continued long after the western was comparatively completed. As it has the more chequered geological history this eastern side will be dealt with first, leaving the west, north, south-central and south for subsequent consideration. And it will be well, at the outset, to bear in mind a fact which is of the utmost importance in arriving at a clear comprehension of the various problems which depend on the physical geology of Africa,



namely, that the continent rises gradually by terraces from the sea-line towards the interior, and that each terrace has an outer rim higher than the terrace itself in that neighbourhood.

18. In those regions where it has its highest development there are present nine distinct features in East Africa, proceeding from the coast towards the interior, to which Gregory gives the names Temborari or coast plain, the Foot plateau, the Nyika, the Primitive Mountain axis, the first Rangatan, the Volcanic Chain, the second Rangatan, the Rift valley and the third Rangatan.

Gregory, G.J., iv, 1894, p. 293.

Meyer, M.P.G., 1891, p. 258.

After Gregory.

Thus before reaching the primitive axis there are three steps or terraces rising one above the other, and these, though varying in width, have a general direction parallel to one another, to the coast and to the primitive axis. "The coastal zone is formed chiefly of raised coral rocks and cemented coral sand, and is covered by sand dunes and raised beaches, and has red soil of windborne quartzose sand." The width of the Temborari, which extends more or less regularly to the Horn of Africa, and is continued round its northern side past Berbera, and also southwards along the coast of the German sphere and of Mozambique, varies very considerably. At Mombasa it is only 2 miles wide; at Takaunga it does not exist, being covered by the hills of red sand and

Koettlitz, G.J., xv, 1900, p. 364.

Carboniferous sandstone, which run right up to the coast and terminate in abrupt slopes; between Meludi and Lamu the average width is 10 miles; at the mouth of the Jub River it reaches inland for 100 miles, but narrows down again between Mogdishu and Obbia, while still farther north it appears to consist more largely of sand dunes and pebbles overlying the calcareous formations, and still retains the character of a narrow band.

Sacchi, map.
Jenner, G.J., xiv, 1899, p. 637.
Bricchetti-Robecchi, B.S.G.I., 1893, p. 359.
1891, p. 269.

19. The foot plateau is not continuously represented, but is, nevertheless, well marked for long distances, and where so present it has been found to consist of Jurassic beds in both the British and German spheres, consisting of shales and sandstones with some beds of limestone; while with these last occur thick masses of red sand and sandstone. Further north these Jurassic beds have entirely disappeared, and the coast plain rises at once to the Carboniferous sandstone hills, while at the Jub mouth and abreast of Obbia the Temborari is succeeded by Mesozoic limestone, with, on the right bank of the Jub, a narrow intermediate zone of clay and red sand, probably decomposed granite, as Sacchi represents it as granite, on the left bank; while further south, in the German sphere, a great Carboniferous block separates two Tertiary coastal areas.

Gregory, G.J., iv, 1894, p. 295.

Peters, map.

Jenner, G.J., xiv, 1899, p. 637.
Sacchi, map.

Bornhardt, map.

20. The Nyika plateau, which succeeds the foot plateau, is bounded on the east by a steep escarpment and consists of vast barren sandy steppes with red quartzose soil. This Carboniferous plateau is carried northwards, and extends also for a great distance and with broad expanse in a southerly direction, cropping out at Nyasa, where it is broken into by the lake and the alluvial deposits to the north of it. It seems probable also that the extensive desert regions in the Portuguese territory spoken of by O'Neill and Maples may form a southern extension of this formation. Spilsbury argues that a coal belt extends, a little north of the 13th parallel at the coast and running north-north-west, from the north end of Madagascar into the interior of Africa. Gibson, on the other hand, gives these beds a much less extensive area and assigns them to the Nubian sandstone period, which belongs to the Cretaceous age. There seems, however, a possibility that they may belong to the Karoo period, which is also coal-bearing, and is of Permo-Triassic age. Gregory and Thomson appear to assign them to the Carboniferous group.

Peters, map.
Moore, G.J., x, 1897, p. 293.

O'Neill, Maples, P.R.G.S., 1882, pp. 79, 193; 1885, p. 437.
Spilsbury, J.A.S., 1901, p. 136.
Gibson, map.

Dantz, M.D.S., 1900, p. 126.

21. The primitive axis is less perfectly preserved in the centre than in the north and south, being frequently buried, in the area occupied by the British and German East African spheres, under such huge volcanic masses as Kenia and Kilimanjaro. This primitive axis consists chiefly of gneiss and schists, and is represented by the Ungweno and Para Mountains to the south of the Anglo-German boundary, by the gneiss mountains of Bura, Teita, and Ongalea or Kyulu, by numerous bare gneiss hills on the Kikumbuliu plain and to the west of Ndangi River, and by Mbinzau. "Further north the line is continued by the gneissose and schistose dome of the Iveti Mountains, and the gneiss ranges of Ithamba, Voroni, and Changabubu on the south margin of

Gregory (*above*).

Von Höhnel, M.P.G., Ergan, No. 99, 1890.
Meyer, M.P.G., 1891, p. 258.
Gregory (*above*).

Kikuyu. Here the gneiss hills disappear below the lavas and agglomerates of Kikuyu and Kenia; but north of this the line appears again in the Doenyo lol Deika, the Loroghi Mountains, and General Matthew's chain and passes northward." Towards the south, as already mentioned, this old axis is continued in the Hoogeveld of the Transvaal and the Drakensberg of Natal. From the constant recurrence of the steep bare hogsback hills of gneiss, and from the constant recurrence of the north and south foliation, as well as from the character of the rocks, Gregory concludes that they must all form part of one common chain. This range, however, has been greatly lowered and broken by denudation and erosion, and all the rivers of the present Indian Ocean slope have forced their way through it at various times and at various points, subsequent to the raising of the new axis further inland.

22. To the west of the primitive axis comes the first of the three elevated plateaux, to which Gregory gives the name Rangatan; and following this again is a series of volcanic peaks, which can scarcely be called a chain, being, as such peaks usually are, scattered sporadically, over a long and broad meridional belt, and succeeded in turn by the second Rangatan, which forms the eastern watershed, and the eastern slope of what once was the range marking the waterparting between the Indian and Atlantic Oceans, and, therefore, the axis of the continent. The Rangatans are covered with the lavas of the volcanic series, and are, therefore, of earlier date. And here one of the most marvellous phenomena has occurred. There existed, at one period, a great chain, extending from the north of Nyasa to the Afar Mountains of Abyssinia, in the form of an anticlinal or arch. There is a second range beginning with the Nyasa–Tanganyika plateau and continued by the great schist range on each side of the last-mentioned lake and of Kivu, Albert-Edward, and Albert, but whether this also was an anticlinal is still *sub judice*. In any case, enclosed by these two ranges lay the great area of internal drainage, the waters of which have since, in the case of Tanganyika, Kivu, the Albert Lakes, and Victoria, found their way to the Congo and the Nile and so to the sea. Now with regard to the more easterly of these two chains, a most remarkable subsidence has taken place. The whole of the central portion of the arch gave way and fell in. And the result is that there was formed a "valley of subsidence," with long steep parallel walls, which Gregory calls a rift valley, and likens to the great Yosemite Valley, and to which Suess gives the name "Graben." The summits of the walls of this eastern rift valley still form the continental parting, the rivers from the eastern summits flowing into the Indian Ocean and from the western to the Congo and Nile, and so to the Atlantic and Mediterranean. On the floor of the Graben, however, is a series of rivers and lakes, extending from Lake Rukwa, just north of Nyasa, to Lake Rudolf, and continued thence to the Red Sea by a low-lying belt, in some places below sea-level.

Gregory (*above*).
Von Höhnel (*above*).

23. Gregory appears to include Nyasa among the lakes of the Eastern Graben, but Moore contends that the changes in the level of the land which have enabled Nyasa to stand where it is

Moore, G.J., x, 1897, p. 289.

now, 1,500 feet above the sea, had nothing to do with a rift. The Nyasa district, including the Shire highlands, is composed, speaking generally, of more or less lofty granitic masses, the axes of which run approximately north and south, but which spread out from each other, enclosing large areas of land, which are now covered with modern alluvium, and constitute extensive malarial flats, one of the most noticeable features of the country. The whole region, except for the narrow rocky eminences which occur in all directions, is composed of a succession of swampy plains at different levels, and of various areas, more or less covered with decomposed granite and gneiss, brought down by the tropical rains. It is true that in the vicinity of Nkata and Amelia Bays there is some indication, says Moore, of the existence of a state of things which might be construed into circumstances attending a rift, namely, a double succession of scarps, with intervening lower land. For in these two districts, on opposite sides of the lake, are stratified masses lying between granitoid ranges, with the same faults and the same scarps; but, unfortunately, it is contended, for the Graben theory, the anticlinal inclinations are wanting. Moreover, Moore points out that the sides of the lake have been raised up, instead of the centre of the arch having fallen in, and that this elevation must have gone on long after Nyasa became a lake. Tanganyika, he says, appears to lie wholly in a series of valleys formed by faults running north and south along the interior plateau, and may be as old as, but cannot be older than, the date of formation of the valleys at the bottom of which it now exists. Whereas Nyasa, on the other hand, was evidently in existence as a lake at a time when similar faulting was going on. There is no geological evidence, he continues, to show that Nyasa is of very ancient origin, but it is at least older than Tanganyika.

Bornhardt, V.G.E., 1899, p. 437.

24. Bornhardt, however, agreeing with Gregory's implication, has no hesitation, after a more recent study of the region, in ascribing the formation of Nyasa to a subsidence of the earth's crust, and he considers that the line of depression is prolonged north of the lake, where it forks into two branches, one passing north-west to Lake Rukwa, the other embracing the Ruaha Valley.

Martonne, Z.G.E., 1897, p. 321. G.J., xix, 1902, p. 43. Sacchi, map.

25. To the west of the eastern rift valley, the third Rangatan, which forms the western watershed, slopes down gradually to Lake Victoria, which thus lies between the two Graben in a basin two-fifths of which is occupied by the lake itself. These Rangatans are composed chiefly of the older volcanic rocks, basalt, diorite, syenite, &c., which cover an immense area stretching over a great meridional belt and reaching from the south of Kilimanjaro, almost uninterruptedly, past Lake Rudolf, and forming the larger part of the Abyssinian highlands.

Kirk, J.R.G.S., 1844, p. 7. Rohlfs, p. 284. Koettlitz, G.J., xv, 1900, p. 264.

The series of volcanic cones, lying mainly between the old and new axes, has strewn the Rangatans with volcanic ashes and lava, and these plateaux are, therefore, rich, and form a great contrast with the barren Nyika. The principal peaks of the chain which quite overshadow the real waterparting are Kilimanjaro, Theuka, Kyulu, Kenia, Teleki's volcano (south of Rudolf), and

the craters described by Koettlitz to the south of Addis Abbaba, if these last really belong to the same series and not to a later disturbance. Wellby, G.J., xvi, 1900, p. 298.

26. From the presence of certain fauna forms in the eastern Graben, which also occur in the Nile, Suess argues that there must have been, at some period, a connection between the two. "If, in addition, we note the existence of the Wadelai–Gondokoro Gorge, where the Nile has forced its way through a lofty plateau having an average height of from 3,500 to 4,000 feet, the river level itself falling from 2,200 feet at Wadelai to 1,600 feet above Gondokoro, we may well ask what was the course of the river above Wadelai before this plateau was breached." In this region is a series of mountains named after various travellers, Schweinfurth, Junker, Gessi, &c., and the waters from the west of these flow to the Congo. It is only reasonable then, to suppose that those rising in the other slopes flowed to Lake Albert, the difference between the beginning of the gorge (2,200 feet) and Lake Albert (2,300 feet) being only 100 feet, and thus the direction of this portion of the river was reversed, the waters finding their way to the Lake Choga system, and thence to Lake Rudolf, by the valley of the Turkwell. There are instances in the extreme south of South America, where, within the memory of man, lakes which used to empty themselves into the Atlantic, now send their waters to the Pacific and vice versâ. We should then have the original Nile rising in the Latuka highlands and flowing northward, subsequently capturing the waters of the great Bahr-el-Ghazal Lake further down. Then came another great period of volcanic activity. Elgon, Lekakisera, and Dabasien were uplifted, and the Wadelai–Gondokoro plateau was rent by a valley of subsidence, the waters of the Choga system were reversed, and turned into Lake Albert, which at the same time discharged its waters through the gorge and created the existing Nile. Lake Victoria was probably in communication with the Choga system before the disturbance which created the eastern rift valley. Gregory, G.J., iv, 1894, p. 512. Suess, Denk. k. Ak. Wiss. Wien, 1892, pp. 562, 579. Moreno, G.J., xiv, 1899, pp. 247, 248.

On the other hand, Hobley thinks that there is strong reason to believe that the Valley of the Turkwell has been recently eroded and entirely formed since the elevation of Mount Elgon, in the crater of which the present river rises; and he is inclined to believe that the outlet of the Nyanza basin to the north was probably by way of the Ruzi Valley, which joins the Sobat near Nasser. Note 323.

27. Anterior to these wonderful evolutions, however, there was a time when the great Ruenzori range did not exist, the country was probably a grassy upland extending from Unyoro, Ankole, and Ruanda, on the east, to the Balegga plateaux. Then came a period of violent convulsion; the Ruenzori range was raised to the skies and a huge yawning gulf was left, 350 miles in length and 30 miles in width. For ages and ages the tropical rains fell and converted the abyss into a lake, whose waters, supplemented by the tributary streams alluded to above (section 26), flowed into the Choga system. Meanwhile the bottom of the gulf silted up Stanley (2), ii, p. 308.

with the sediment and debris of Ruenzori and the surrounding high ground "with the remains of unaccountable generations of fish, with unnumbered centuries of dead vegetation," until gradually clusters of islets appeared, which in turn caught the soil and rocks brought down by the glaciers. Moraines connected rock with rock, and eventually three lakes were formed, Kivu, Albert-Edward, and Albert, for at that period Kivu belonged to the Choga system and not to the Congo. Then followed the period of volcanic activity which breached the Wadelai–Gondokoro plateau, and from that remote date the enlarged and perfect Nile has existed. "The outflowing waters washed the earth away along its course down to the bed rock, and, for countless ages, through every second of time, it has been scouring away atom by atom, to form Lower Egypt and fill the Mediterranean." A final upheaving, the upraising of the giant Virunga, bereft the Nile system of Lake Kivu, and turned its waters, through the Rusisi, a rushing violent stream, into Tanganyika, and so to the Congo. Stanley draws the following picture of the geological changes as they are taking place to-day: "On each side of the forest there are plains . . . and on these lake borders you will see yet an intermediate stage in the daily increasing mud, and animal and vegetable life add to the height of it, and presently it will be dry ground. Now dip a punting pole into the shallows at the south end of Lake Albert, and the pole drops through 5 feet of ooze. It is sediment brought down from the slopes of Ruenzori by tributaries into the Semliki, and thence by the Semliki into the still waters of the lake. And if we sound the depths of Lake Albert-Edward, the pole drops through 4 or 5 feet of grey mud, and to it are attached thousands of mica flakes and comminuted scales and pulverised bones of fish. And atom by atom, the bed rock between the forest of Awamba and the Lake Albert-Edward is being eroded and scoured away, until, by and by, the lake will have become dry land, and through the centre of it will meander the Semliki, having gathered the tributaries from Ruenzori, the Ankole, and Ruanda uplands to itself; and, in course of time, when the nitrous and acrid properties have been well scoured off the plain, and the humus has thickened, the forest of Awamba will advance by degrees, and its trees will exude oil and gum, and bear goodly fruit for the uses of man."

Moore, G.J., xviii, 1901, p. 1, *sqq.*

Stanley (*above*).

Moore (*above*).

28. The Jurassic and Carboniferous rocks which occur in the area have already been alluded to. With the exception of the Karagwe beds and the basin of the Malagarasi the whole of the remainder is composed of igneous and metamorphic rocks. In the whole of the Upper Nile basin there is not a vestige of any of the newer formations, nor further south are there any traces, except the alluvium of the valleys and marshes. The gneisses and schists have an enormous extension throughout the whole of Equatorial Africa, and form the main plateau on which all the sedimentary and volcanic rocks have been deposited. Granite appears along the major axis of Lake Victoria, both on the north and south, while the gneisses and schists are found along the extension of the minor axis. The collection made by

Martonne, Z.G.E., 1897, p. 315. Scott-Elliot and Gregory, Qr. J., 1895, p. 676.

G.J., xix, 1902, p. 43.

Johnston, Wilson, Racey, Grant, Hobley, Isaac, and others, shows that the main mass of the Uganda plateau is made up of the Archæan gneisses, schists, and granites, specimens coming from Busoga, Bukedi, Elgon, Unyoro, Ruenzori, and the Nile province. The Karagwe series of Palæozoic rocks extends from the north of Tanganyika, curving round the east of Kivu to the east of Lake Albert-Edward, and occurs again on the eastern shores of Lake Albert, and also at Ujiji on Tanganyika. This series consists of granular quartzites, coarse schistose sandstone, red and brown sandstones containing beds of hæmitite, and a series of argillaceous beds, which range from shales to a well cleaved killas. Further south the prevalence of the schists led Baumann to name the range in which Tanganyika lies the Central African "schist range" (Schiefergebirge). All the region west of the Tana, and a great part of German East Africa, as well as the Ruvuma basin are made up of gneisses and schists. From such knowledge as we possess of the Horn of Africa from the Jub River northwards is a region of Mesozoic and Tertiary limestone overlying granites, gneisses, and schists. How far south this limestone extends is at present unknown. On the right bank of the Jub, Jenner records that it begins (going north) near Saloli, a little south of 1° 30′ N.; and is the prevailing rock of the country to the north. The second Bottego expedition found, in going up the left bank of the river and crossing from above Lugh to Lakes Stefanie and Rudolf, massive granites, diorites and syenites, and gneiss and schists, overlain by calcareous Mesozoic rocks, probably of the Jurassic age, and gypsiferous sandstones and Bunter Sandstone. In the neighbourhood of the lakes were found basalt, andesite, trachyte, liparite, and volcanic tuff. Similarly Bricchetti-Robecchi, on his way inland from Obbia to Bari and thence northward to the coast, speaks of the ever-recurring limestone. The thickness of this formation reaches 250 feet in some places in Northern Somaliland; and a band some 200 feet in thickness appears very generally over that part of the country, and is eaten into caves at its outcrop, where it overlies unfossiliferous sandstone of an average thickness of 800 feet.

Baumann, p. 133. G.J., iv, 1894, p. 122. Peters, map. Dantz, M.D.S., 1900, p. 126.

Livingstone, (1), i, p. 83. Jenner, G.J., xiv, 1899, p. 637.

Bricchetti-Robecchi, B.S.G.I., 1893, pp. 822, *sqq.* Parkinson, G.J., xi, 1898, p. 15. Note 322.

British Somaliland is divided into two sections by the water parting which crosses the boundary nearly due south of Zeila, and trends in an easterly direction through Hargeisa, Upper Sheikh, and Negegr, approximately parallel with the Gulf of Aden coast-line. This ridge forms the northern boundary of Ogo, the great plateau of Somaliland, and also of that limestone and sandstone formation, which exists in most of the southern, and by far the larger portion of British Somaliland. This series lies nearly horizontally on the Archæan granite, gneiss, and gabbro, the sandstone and limestone beds dipping slightly in broad undulation to the south. The maximum dip is probably found at Upper Sheikh, where it varies from 6 to 10 degrees. Comparatively recent deposits of gypsum and alluvium cover this series in the vast plains to the south. The limestone, which has now been pronounced to be of Eocene age, lies conformably on the sandstone, and the passage beds consist of sandy limestone con-

Note 322.

glomerate, carrying mostly fossil shells. The thickness of the sandstone, as mentioned above, is probably about 800 feet. The announcement, now first made, that this great extent of limestone is Tertiary, coupled with the interesting discovery of fossil remains (sea-urchins and a nautilus) of the same age by Gaden 400 kilometres west of Zinder, and the previous discoveries of Tertiary sea-urchins, both at Bilma oasis and in Baol, tend to confirm the belief that an arm of the sea extended right across Africa in Tertiary times. North of the water parting the formation is much broken by a series of faults, through which the country has subsided in a series of steps to the coast, ultimately forming the Gulf of Aden.

B.S.G., vii, 1903, p. 417.

IV.—*Northern Africa.*

Rolland, p. 231.

29. No complete study has yet been made of the Maroccan Atlas, but we know that its geological constitution differs very largely from that of the Algerian and Tunisian Atlas. For, while the latter are formed of comparatively recent rocks of the Secondary and Tertiary periods, viz., Jurassic, Cretaceous, and the younger series, in the former are found chiefly crystalline and eruptive rocks, granites, diorites, porphyries, dolerites, &c. together with Palæozoic and Permo-Triassic beds, argillaceous schists, calcareous rocks and marbles, red sandstones, and conglomerates. Dr. Fischer found, on the northern slopes, conglomerates on the Tensift. North of Marocco city he found schists (alte Schiefer), and north of this again the steppe country consists of Devonian clay-slate (Thonschiefer) with quartz. Then again, south of Nsim, is Old Red sandstone, and further north, conglomerates, and the same formation on the left bank of the Tassaut, before its junction with the Um-er-Rbia. The Ait Robaa district of the Atlas is composed of grey and black shales, with beds of quartzites, and east of Marocco city are quartzites overlying grey and black shales. The southern slopes of the tail of the Atlas are of limestone and cretaceous sandstone, but the mass of the Anti-Atlas is formed of chains of palæozoic schists.

M.P.G., Ergan, No. 133, 1900.

Harris, G.J., v, 1895, p. 321.

Thomson, P.R.G.S., 1889, p. 1.

Lenz, p. 290.

Schirmer, p. 6.

30. The Sahara is geologically a very simple region, the different formations appearing in regular beds, extending over immense areas. A great zone of the earliest rocks covers the southern and western portions. Tibesti and its continuation to the south, Air with its granite and old basalt, and the granites of the Ahaggar plateau in the south, as well as the granites of El-Eglab, of Nun and of Tiris in the west, are all representatives of the ancient crystalline foundation of the continent. Around these are grouped the deposits of the Palæozoic seas, the dark sandstone flanking Tibesti, Borku, and Kawar, those of the Tummo plateau to the south of Fezzan, the region north of Ahaggar, and encircling the oasis of Air; while Silurian, Devonian, and Carboniferous deposits are widely diffused towards the west, being

Nachtigal, I, p. 391.

Barth, p. 349.

Lenz, M.P.G., 1882, map.

*Douls, B.S.G., 1888, p. 456.

*Quiroga, p. 337.

v. Bary. Z.G.E., 1880, p. 3.

Lenz, II, p. 50.

* Quoted by Schirmer.

found so far west as Wad Ghir, and north and south of the Igidi dunes. During the Devonian period the sea covered a very large portion of Western and Central Sahara. An emersive movement was then produced in the central parts, but the Carboniferous sea occupied Western Sahara and the regions of the Atlas of Morocco. The complete and definitive upraising of Western Sahara must have taken place at the end of the Carboniferous period, and it is probable that this was synchronous with the upheaval which twisted and folded the original mass of the Moroccan Atlas, the final raising of which must have been an event of a later date, because of the existence of a development of Permo-Triassic beds lying unconformably on the Palæozoic. But since the close of the Jurassic period the western part of the Atlas has been sub-aërial, forming a salient pushed out into the Atlantic. The Western Sahara has been dry land since the Carboniferous period, and so, too, has the Central Sahara, except in the north, where there was a Cretaceous immersion. It has long been recognised that the rocks of the Devonian period extended over large areas in the Eastern Sudan. Barth's companion, Overweg, was the first to establish this fact by securing fossils of the period, and since then the existence of these beds has been confirmed over and over again by various travellers. But in the Western Sahara, though the Devonian was supposed to exist, its presence was accounted for only by a single fossil. Now, however, the French expedition to Twat, under Servière, has returned with many specimens, which conclusively prove that the west of Gurara, Wad Saura, and the depression of the Twat oasis, are undoubtedly Devonian, and the formation most probably extends to the northern and western parts of the plateau of Muidir. South of the Atlas the Palæozoic beds lie out horizontally, and form great "hamada," consisting of sandstones, schists, and calcareous rocks, and extending across the Western Sahara. These are assigned by Lenz to the Devonian and Carboniferous ages. Tafilet marks the eastern limit of the great Devonian hamada, and forms at the same time the western boundary of the Cretaceous hamada of Northern Sahara. Most of the Devonian beds consist of very dark sandstone, almost black, but white when fractured, and very hard, forming plateaux with high steep escarpments, the beds themselves being in great part horizontal, or nearly so, throughout the whole of their very large extension. In the east, where the Palæozoic formations stretch along the southern foot of the Cretaceous Tripolitan plateau, and form a large part of Fezzan, traces of strata of the Carboniferous age have been found.

Rolland, p. 255.

Flamand, A.F., Supt. I, 1902, p. 3.

Rolland, p. 231.

31. Of the Secondary rocks, the most ancient, namely, the Triassic and Jurassic, are not present in the Sahara, at least they have not yet been observed, but those of the Cretaceous period are largely represented. During the Cenomanian (middle *Cretaceous) epoch, the Mediterranean covered the Algerian and Tunisian Atlas region, the Algerian and Tripolitan Sahara and the north of Eastern Sahara. On the west it bathed the eastern flanks of the Moroccan Atlas, to

Schirmer, p. 8.

Rolland, p. 256.

* See note on p. 22.

the north of which a channel communicated with the Atlantic. In the south-west it was arrested at the confines of Western Sahara, which thus lay between two seas, while in the south its banks ran from west to east, forming the southern boundary of Eastern Sahara, and its waters reached to the crystalline region bordering on the Red Sea. The *Cretaceous formations include the red-brown nummulitic sandstone of Nubia and the Libyan Desert, from Kordofan to the confines of Kufra and Dekhel, and the entire foundation, so to speak, of the Algerian and Tripolitan Sahara appears to be upper and middle Cretaceous, Cenomanian (greensand), Turonian and Senonian (chalk-marl and chalk), sometimes exposed as in the plateaux of Tinghert and Tademait, sometimes covered as at Mzab. There is also a Cretaceous coast belt extending southwards from the Tensift, including Jabel Hadad, and past Mogador at least as far as Agadir, and continued again from north of Cape Juby to Cape Blanco. Cropping out from the *Eocene beds of Egypt is an Upper Cretaceous limestone escarpment occupying portions of the oases of Farafra, Dakhla and Kharga, being broadest at the first named, and narrowing southward from the last, and then making a southern semi-circular curve through Dungul, and continued northwards to Esna. On the east side of the Nile this narrow band is continued eastwards; the escarpment also extends westwards from Farafra.

Zittel, map. Rolland, p. 85. Rolland, B.S.G., 1880–81, p. 538. Choisy, p. 125. Thomson, P.R.G.S., 1889, p. 1. Ball, map. Beadnell (1) and (2), maps. Lyons, Qr.J., 1894 (Nov.).

32. It appears then, from what has been said, that, at the end of the primary era, a large part of Western and Central Sahara was above water, and that, by the beginning of the Tertiary age the greater part of the Libyan Desert, Tripolitan Sahara, and the plateaux of the Algerian Sahara had become dry land. Before the end of that epoch the huge open gulf extending from Tripoli to the crystalline mountains, which fringe the Red Sea, had been filled up, and Messura Gulf had changed into the Wad of that name. In fact, by the end of the Miocene period, the whole of North Africa, nearly all the Atlas region, and the whole of Sahara, from the Atlantic to the Red Sea, formed part of the continent, the Pliocene and Pleistocene periods being accountable for no sensible change in the west; while in the east the definite contours of the Egyptian coast, though altered, are due rather to an invasion of the sea. The expedition, of which Zittel was a member, failed entirely to find any traces of more recent date than the Miocene. This explorer also adds that in the whole configuration of the terrain there is no single characteristic which points to the Sahara being a recently dried-up sea. The non-marine representatives of the Pliocene and Pleistocene periods are, however, met with in the alluvial coverings of the lower parts of the Algerian Sahara and Fezzan, forming the great plains from which the cretaceous peaks peep out, being those portions, already alluded to, where the Cretaceous formations are covered. All the Egyptian region was raised from the sea at the close of the Eocene period, there being no Miocene strata present in this area, except in the

Schirmer, p. 11. Le Chatelier, B.S.G., 1886, p. 365. Rolland, p. 259. Zittel, p. 21. Rolland, p. 161. Hull, Qr. J., 1896, p. 308.

* Alluded to above, p. 21, by Rolland, as Cretaceous. It should be noted that a great part of the Nile valley, in Egypt, is a fault valley.

coast zone on either side of the Nile delta. And during this latter period elevation and disturbance of strata and denudation were taking place to a great extent, the erosion by old river action being most noticeable. Subsequently, in later Pliocene times, there were great inundations extending into the Pleistocene period, and Lower Egypt was submerged to a depth of 200 feet, the sea extending up the Nile Valley for several hundred miles. It was during the Miocene period that the Lower Nile wore its way deep down into the tableland, through the *Eocene limestone to a depth of from 800 to 1,000 feet, forming a valley with an average breadth of some 10 miles. In this connection it is interesting to note that at present, as stated by Hull, the erosion in the Lower Nile has ceased; that, in fact, the bed of the river is rising, because, if this were not so, the water of the river could not reach the cultivated area on its banks, for these latter are undoubtedly rising above the sea-level in consequence of the continual laying down of the matter brought down by the stream.

33. Coming now to the consideration of the extreme south of the Sahara, of the Sudan, and of the country occupied by the various colonies and spheres of influence on what is generally known as the "West Coast," we find that an enormous zone of granite, gneiss, and crystalline schists extends almost from the coast on the west to beyond the Upper Nile regions on the east. This huge mass of the oldest rocks does not, however, as might have been expected, had there been only the experience of our own continent to judge by, form a core of a huge mountain range, or system of ranges, on whose flanks lie the deposits of succeeding ages, but on the contrary, is of small elevation, having been reduced through endless ages by erosion and denudation. On portions of this mass lie the marine deposits, horizontally as a rule, or nearly so. In Kordofan the soil is granite sand mixed with clay, the plateau being crowned with granite blocks, and Jebel Kordofan itself consists of granite, flanked by mica-schist and gneiss, so, too, does Jebel Habila. West of Delen is a small granite range, Wodda consists of low granite hills, Golfan is composed of granite and crystalline schists, and the same rocks are found in the Tagoi hills, which rise from 200 to 300 metres above the surrounding plain, though Jebel Tagoi itself is of gneiss, while southward from Kadero to Kawalib is sand with low granite hills. Further south, in the Bahr-el-Ghazal region, is gneiss detritus with granite-crowned hills, and from below Lake Albert to the confines of the Sanga River extends a band of granite and crystalline schists. The A-Zande plateaux, again, have a gneiss subsoil, relatively friable, levelled by the action of water, and covered with ferruginous conglomerates and clay, and reaching from the Upper Sue River and Iba River to Darfur and Wadai. The whole Ghazal region is of laterite overlying gneiss and granite. Jebel Mangayat and the adjacent heights are of granite, so also are the valleys of the Sue and of the tributaries of the Bahr-el-Arab. Jebel Marrah, in Darfur, is a series of volcanic peaks, but these,

Marno, p. 198.

Linck, V.G.E., 1901, p. 217.

Junker, ii, p. 145.

Cornet in Wauters, p. 115.

Cureau, M.G., 1897, p. 600.

B.S.G., iv, 1901, p. 268.

Junker (a), ii, pp. 79, 116, 120, 321; iii, pp. 16, 34, 72. Cureau (*above*). Mason, M.P.G., 1880, p. 377.

* See note on p. 22.

Prins, B.S.G., 1900, pp. 179, *sqq.*
Clapperton (2), Pt. ii, pp. 70–72.
Peroz, R.G., ii, 1901, p. 469.
D'Albeca, B.S.G., 1895, p. 192.
Toutée, A.G., 1897, p. 136.

again, rise from a granite plain. Going farther west, it is found that Dar Runga and the whole country in the vicinity is composed of granite rocks, with argillaceous sands in some places, and the mountains are generally capped with rounded granite. In the Niellim country, near Gail, where the Shari River makes a great bend, it is encumbered by huge granite blocks, and Togbao Mountain and other hills in the neighbourhood have granite summits. To the west of Lake Chad, Clapperton tells of the granite hills to the west of Zangaia, and of the schists west of Kandania, of the granite ridges and huge blocks of granite at Geoza, at Reta and at Birshi, and of the red ferruginous clay and decomposed granite everywhere. While in the north, as reported by Peroz, the granite appears at Zinder. In the hinterland of the

Wolf, M.D.S., 1888, p. 101.
Chanoine, B.S.G. Comm., 1897, p. 752.
Trotter, G.J., x, 1897, p. 246.
Barth, iv, p. 271.
Lugard, G.J., vi, 1895, p. 214.
Salesses, B.S.G., 1899, p. 384.
Thomasset, A.F., 1900, p. 166.
Weissgerber, B.S.G., iv, 1901, p. 235.

west coast we have the mountains of Nupe and Upper Dahome, of Togo and the eastern portion of the Gold Coast, of Gurunsi, of Baule, and of Koranko, as well as the Karabe district, all of which are composed of the oldest rocks, gneiss, and crystalline schists, with granite. Lugard also bears witness to the fact that Borgu is principally made up of grey granite and the copper coloured ironstone which forms the prevailing feature in West Africa. In French Guinea the district of the upper coast streams, and the water parting between this district and the Niger, as well as the whole of this part of the Niger basin, is granitic, while Futa Jallon is surrounded by a rampart of granite mountains. Finally, behind the coast hills of the Ivory coast, the inland portion of this French Colony is made up chiefly of gneiss and mica schists, overlying which is a thin layer of vegetable humus, but the whole of the middle and lower Sassandra region is of granite.

Dereims, A.G., 1900, p. 458.

34. The coast belt north of St. Louis, at least as far as Marsa, is a great plain sloping gently to the sea, probably Pliocene, sometimes with shell marl, sometimes with gypseous crystals. These crystals have on earlier occasions been erroneously described as mica. This country is not of the Sahara type, but, says Dereims, is a northern prolongation of Senegal country. If this were the case it would be a laterite country, which does not seem to agree with the above. Numerous dunes appear with a general north-north-east direction, covered with vegetation, and this type of country extends for 200 kilometres from the coast. Eastwards of Twizikt the soil is composed of sand and ferruginous quartzites, with traces of quartz and manganese. Numerous faultings run north and south, and the beds have a westerly inclination. The entire surface has here been levelled by erosion. This kind of formation extends over 100 kilometres as far as Tabringut, and then occurs the crystallophylline plateau, which extends from the Sebkha of Ijil on the north, to Bakel on the Senegal River, and is terminated by an abrupt cliff 175 metres high, and extending for the same distance. Here the quartzites and sandstones are perfectly horizontal. The plateau of Adrar forms a portion of this district. The upper valleys of the Niger and Senegal traverse great beds of sandstone, folded at the base, but horizontal at the summit. Here also are found siliceous and crystalline limestones.

Rambaud, p. 225.

All these beds lie on the primary schists, sometimes micaceous, and frequently accompanied by granite and quartz. The sandstone mentioned above is likened by Rambaud to Karoo beds, but Scott-Elliot tells us that the plateaux of Talla and Falaba, which appear to have a similar crystalline base, are partly covered by horizontal beds of sandstone, which resemble the Nubian formation. In Senegal an examination of the Kayor and Baol districts shows that the country consists of various rocks, which were folded and faulted by the violent earth movements which accompanied the upheaval of the volcanic mass of Cape Verde, the whole covered by a great thickness of sand and laterite. Kinsam Mountain region is also overlain by the same formation, and so, too, is the Diagissa plateau.

Scott-Elliot, C. 6998.

Rambaud (*above*).

Maclaud, L.P.C., 18/8/99.

In our colony of the Gambia, on either side of the river, there is, for the most part, a fertile but light sandy soil; here and there are small hills of laterite, which, from Ballanghar on the North bank, and all that portion of the South bank from close to where the Vintang Creek joins the river to the boundary east of Yarbutenda, take the form of a low ridge varying in height and situated at different distances from the river, though following, as a general rule, its course. Laterite is the only kind of rock noticed in the Gambia Territory, and it is probable that no other exists.

Note 317.

In Sierra Leone there is generally a covering of laterite over all ground, excepting the narrow alluvial coast belt, up to an altitude of 1,000 feet. Farther inland, also, the same formation appears in the neighbourhood of Bassikunu, and westwards from Bachuinet are laterite and clay-slate (Thonschiefer), while southwestwards from Nioro lies wooded country, followed in the same direction by laterite. Our knowledge of the West Coast is very meagre, owing, no doubt, to the inaccessibility of the country in consequence of the existence of the great equatorial forest belt. We know, however, of the existence of alluvio-laterite terraces on the Benin coast in the neighbourhood of Porto Novo, and also near Abome, as well as on the coast of Togo, and we know also that these terraces alternate with beds of sandstone and clay. Again, on the Lagos coast the soil is a strong red clay, the country rising gradually to Chocho, while further inland is a range of grey granite hills running west-north-west to east-south-east, followed by soft crumbling granite.

Scott-Elliot (*above*).

Lenz, map.

D'Albeca, B.S.G., 1895, p. 187.

Toutée, A.G., 1897, vi, p. 136.

Clapperton (2), p. 56.

Barth (a) vol. iv, p. 104, map.

From the geographical distribution of rock-specimens examined, Geikie concludes that our Colony of Lagos is built up essentially of gneiss—that rock appearing to occur almost everywhere throughout the region. Associated with it in some places (as at Aro, Ibadan, Ondo, Jebu, &c.) are mica-schists. This schist appears to be much decomposed, and it may thus often lie concealed under the product of its own decay. The relative absence of amphibolites is noteworthy. In keeping with this is the great development of granite and its varieties, and the rarity of diorite and syenite. Briefly the geology of Lagos presents a complex of dominant granitoid gneiss, with important zones of quartzite, and subordinate developments of granulite and amphi-

Note 320.

bolite. Piercing the gneisses and apparently in some places passing into them are masses of granite, along with veins and dykes of haplite and pegmatite. The more basic plutonic rocks play an unimportant rôle—syenite appearing only in one place, while the diorites are of rare occurrence and are hardly typical of their kind, most of them containing a high percentage of quartz. The whole complex is thus markedly acidic.

Note 321. Some upheaving force seems to have affected portions of the Niger delta, because, in places, land 20 feet or more above sea-level is found close to the mouths of the rivers, although surrounded for some miles inland by mangrove swamps (*e.g.*, Oron, at the mouth of the Cross River). Reports, as yet, however, unauthenticated, appear to show that the country between Degema and Owerri possesses characteristics inconsistent with a simple delta formation (*e.g.*, a ridge, said to be of rock, traverses the creek near Nsokpo).

The West Coast sedimentary deposits, where they cover the ancient crystalline rocks, consist chiefly of red sandstone and ferruginous conglomerates, which are largely represented in the north, notably in the Mossi and Say regions. All these rocks have been subjected to long-continued denudation, and are consequently worn down and the country rendered comparatively level. As a matter of fact, the whole of the region lying behind the coastal belt, as far as the northern limit of the forests, has become what is usually termed a peneplain, that is, a land surface which has been reduced to a condition of low relief by erosion. And if a great part of this area were not now so covered with forest, the rocky sub-soil would doubtless everywhere be laid bare, and the alluvium would find its way to the lagoons which fringe the coast.

Monteil, p. 150.

Thomasset, A.G., 1900, p. 159.

Dreyfus, p. 288.

Notes 318, 319. The Gold Coast Colony and Ashanti consist of two main areas, separated by a lesser, which forms the chief waterparting of the country, a comparatively narrow belt of regional metamorphism defined by the Akropong, Akim, Begoro, Kwahu, and Mampon Hills, and the sandstone plateaux of Nkoranza. The rocks of this parting consist of sandstones, basalt, and coarse gneiss; the last-named of which has by decomposition formed the alluvium of the valleys, where thick veins of quartz are frequent. The open plains of the Volta River basin, forming, with the undulating forest country, the above-mentioned areas, comprises a country in which the horizontal strata of sandstone and shales predominate, yielding a fairly rich alluvial soil. The immediate neighbourhood of the Black Volta River consists of volcanic agglomerates from Tintankru to Akrosu; thence to Nkami, where towering peaks occur, are indurated slates and shales; thence to Mem are the same formations with quartzites; between Mem and Senki is quartz, while granite, gneiss, and schists occur between Senki and Kpong. The southern area is one of (1) contact metamorphism, and consists of crystalline rocks, gneisses, and schists, associated with granite, *e.g.*, in the valley of the Pra, and at Insuaim and Animaboe, and (2) sedimentary rocks, such as sandstones and variegated shales about Elmina, Akra, and Animaboe, slate and beds of conglomerate around Tarkwa.

35. The history of the Niger has not entered prominently into any description of this part of the continent, so far as the compiler is aware. The North African section of this introduction will, therefore, be concluded with a few words on this most interesting feature. As it at present exists, the Niger consists practically of three different rivers, two of which are tropical, the intermediate section being a desert stream. The tropical rains of Futa Jallon feed the streams which form the Upper Niger, and during the rainy season, from Bamako downwards, the river expands and covers the plains and feeds the innumerable lakes, and if the evaporation were not so great in this region there would probably be enough water to carry the river to the sea. This first river ends at Timbuktu. The second or desert river flows through sand dunes without rain and without affluent, the few water channels which cross the country being lost in the sand. The stream is even meagre at Tosaye and thenceforward has a struggle for existence, but at Say it re-enters the tropical region, and the rains commence afresh; feeders join the stream, and the third Niger begins. As a general rule rivers have less and less slope as they near the ocean, unless they happen to cross a range of mountains as the Congo does near its mouth, but with the Niger it is different. From its source to Bamako, a distance of about 375 miles, it falls from 2,800 to 860 feet, this last figure being derived from the latest survey. But between Bamako and Timbuktu the fall is only 1 foot in between 9 and 10 miles, the altitude of Timbuktu being 810 feet, and the distance between the two places between 450 and 500 miles. The fall here, therefore, is practically inappreciable. Finally from Timbuktu to the mouth is about 1,250 miles, and therefore the fall, though still very small, being about a foot in every mile and a-half, is nearly seven times as great as between Bamako and Timbuktu, where we have the basins of the Joliba and the Bani or Bagoe, occupying, so to speak, a dead level, the rivers receiving tributary streams from the heights north of Bamako, from the Kenedugu uplands, and from the plateau of Hombori. Further, a very large portion of this basin (extending over an area from 15° N. to Timbuktu and from Bassikunu on the west to the Bambara Mande on the east) is to-day occupied by almost innumerable lakes, several of which are of considerable size, such as Debo and Fagibini. Now a glance at the map shows that this basin is occupied by Pliocene and Pleistocene beds, surrounded by Palæozoic rocks on the west and south, and by the Kenedugu and Hombori Mountains on the east, and this fact, taken in conjunction with the existence of the gorge at Tosaye, leads almost inevitably to the conclusion that this basin was once the site of an enormous lake. The Pliocene and Pleistocene deposits brought down from the neighbouring higher land gradually, through ages, filled up the bottom of the lake, which at the same time grew fuller and fuller until at length, the precipitation being greater than the evaporation, the lake burst its way through the gorge, leaving the outflowing waters to find a path for themselves. The gorge was gradually deepened and the waters continued their flow, until to-day we have the last

vestiges of the inland sea in the lakes already mentioned, and the Joliba has pushed its way gradually through the sandy desert, increasing day by day in length, until at last captured by the Upper Niger or Tafassasset on its way from the Ahaggar plateau on the north to the Gulf of Guinea on the south. And the Tafassasset now loses itself in the sand and the Niger has its head waters on the slopes of Futa Jallon instead of the plateau of Ahaggar, and is preserved as a perennial stream by the lakes of Timbuktu, just as the Nile is by the influence of the Nyanzas.

V.—*Western Africa.*

Cornet in Wauters, p. 115.
M.G., 1900, p. 3.

36. Of the Great Congo basin, which is in the form of a quadrilateral with diameters of from 15° to 20°, but which suddenly contracts between Stanley Pool and the Atlantic to a width of 1° or 2° or even less, the peripheral regions consist almost entirely of mountains or more or less elevated lands of Archæan and Palæozoic origin; the lacustrine horizontal formations on the other hand occupy the central portions; but this general plan is not limited to the Congo basin, being also the prevailing architecture in most, if not all, of the neighbouring basins, in fact of the whole of Central and South Africa. In the south of the Congo basin the Archæan rocks cover only small areas, notably such mountain regions as are occupied by the Bia and Hakansson Mountains. Granite, passing not unfrequently into gneiss, is also found in the Nzilo Mountains, and at certain places along the courses of the Rivers Kamolondo, Lubudi, Lomami, Luvoi, Kilubilui, Luembe and Sankuru, as well as in the Congo-Zambezi parting and in the extreme south-east of the basin. In certain localities, notably in the valleys between the Upper Sankuru and the Kwango, the upper surface of soft sandstone has been worn entirely away, and the underlying granite or gneiss is exposed. In the extreme west the peripheral region is entirely crystalline, but it is here difficult to distinguish the Archæan rocks from those of later metamorphic age. In the north are large areas of granites and crystalline schists, as is shown by the constant recurrence of such rocks at nearly all the falls of the great rivers, the Ubangi, the Welle, the Bomu or M'Bomu and their various tributaries. The whole basin of the last-named is underlain by gneiss and schists. On the north bank of the Ubangi and in the basin of the Kota River, that is between Wango on the M'Bomu and Mobaye, the substratum is covered by clay and sand, the most frequent rocks being granite and schists. The crystalline rocks in the neighbourhood of the Congo-Chad parting, and stretching from Albert Lake to the Sanga, have already been alluded to (section 33), and in the neighbourhood of the Wom these crystalline rocks frequently emerge from under the sedimentary covering and form chains of mountains. In the east granite and the crystalline schists are largely represented in the districts adjacent to the western "graben" as well as Lakes Mweru and Bangweulu, and also along the upper courses of the

De Mezières, B.S.G., ii, 1900, p. 307.
Julien, B.S.G., iii, 1901, p. 112.

Herr, A.G., 1895/6, p. 318.

Baumann, Pt. ii, pp. 133-260.

eastern affluents of the Lualaba, Aruwimi, Lowa, &c. In the Katanga region Cornet found, especially in the neighbourhood of the Upper Lualaba, important series of sedimentary formations of pre-Cambrian, Cambrian and Silurian origin. In the same locality, as well as in the basin of the Lufila and the Upper Luapula, he found extensive beds of schists, sandstone and calcareous rocks of, probably, the Devonian age, and similar formations along the Lower Congo and from Matadi to Leopoldville. There are also representatives of this period to be found between the Congo and the Welle and on the Itimbiri-Rubi. At some period, prior to the Carboniferous age, one immense lake seems to have covered the entire "lake region," including the whole valley of the Congo and Tanganyika, and extending to the west coast ranges, with a small continent or group of islands in and about Katanga, for, from three separate periods of earth folding, which he was able to recognise, Cornet concludes that, in this region, there were at the beginning of the pre-Cambrian age such outstanding areas of Archæan rocks, and that large districts were subject to meteorological influences during the Devonian period. When the main body of the waters was drained off only great sheets were left in the deeper hollows, and in these were deposited the later formations of West Africa.

Stanley (2), i, p. 207.

Cornet in Wauters, pp. 120, *sqq.*

Thomson, ii, p. 84.

Cameron, ii, pp. 308, 312.

Cornet (*above*).

37. The Monts de Cristal range, says Dupont, was probably upheaved at the end of the Triassic period, and the whole of this part of the continent has since that date been sub-aërial. In 11 separate depressions were collected the remains of the pre-Carboniferous sea. The Congo, if such a river existed, must have been a mountain torrent rushing down from the Monts de Cristal and carving out its short course to the sea. In time the vast central lake which occupied the region nearest to the coast range, and the last remains of which are found in Stanley Pool and other expanses fed by the Inkissi, Alima, Panga, Mongalla, Rubi, Aruwimi, Ruki and such streams as are now represented by the Lower Ubangi, Lomami and Lualaba, began to swell. The precipitation was greater than the evaporation, the water gradually mounted, laying down sedimentary deposits along the eastern slopes of the coast range, similar to those laid down further inland in the 10 remaining depressions. As soon as the waters reached a sufficient level, they forced their way through a gorge and began the descent to the ocean by what are now known as Livingstone Falls. The force of the torrent and the weight of the mass of water behind it gradually enlarged the gorge and deepened it, thus permitting the outflow from, and causing the depression in level of the lake, until nothing now remains of it but Stanley Pool and Lake Leopold and Lake Tumba. Meanwhile a lake was occupying the low-lying portions of the basin of the Welle terrace above the Zongo gorge, another the bas-fond of the Kassai terrace above Kwamouth, and a similar lake the Kamolondo terrace above Hinde Falls, where there is still left a series of sheets of water to testify to the former existence of this inland sea. The terraces of the upper zone were in like manner the sites, as they most of them still are, of lakes of varying size and shape. Of the seven

Dupont, M.G., 1888, p. 22.

Wauters, p. 138.

M.G., 1899, p. 157.

terraces of this upper zone that of Tanganyika is the lowest, whilst the most elevated are those situated at the extreme limits of the basin, viz., those of Kivu, Bangweulu and Lukuleshi. The Kivu terrace (lake) is 2,141 feet above the level of the waters of Tanganyika, the altitude of the former being 4,841 feet and of the latter 2,700 feet. Kivu, however, as already pointed out (section 27) did not always belong to the Congo system, but, after the upheaval of Virunga, in time its waters found their way to Tanganyika through the gorge, where the Pemba Falls, discovered by Lange and Long in 1895, are situated. The waters of the Bangweulu terrace, of which the approximate altitude is 1,200 metres, similarly found their way to the Mweru terrace and lake below, a drop of 310 metres, through the gorge forming Johnston Falls, which were visited by Gerard in 1883, by Sharpe in 1890, and by both Weatherly and Brasseur in 1898. The Lukuleshi Lake or rather its site is little known, but it is probable that its waters forced a passage through the Mitumba Mountains in a similar manner to those already mentioned. The waters of the Nzilo terrace also found a way through these mountains, through the gorge of the same name, where the Delcommune rapids, extending over a stretch of 70 kilom.s., are enclosed on either side by precipitous rocks from 300 to 400 metres high, and the Nzilo River is confined within the narrow limits of 30 to 50 metres. The ancient lake of the Lufila terrace probably extended from the hot springs of Moisha to the falls at Kiubo Gorge, and gradually forced its waters by a succession of rapids to Lake Kisale in the Kamolondo terrace below. Mweru, which like Bangweolo is gradually drying up, sends the combined waters of the two lakes over the Kanke Falls and through the Kiwele (Kivele) Gorge to the great central basin. The last and lowest of the lake basins of the upper zone, that of Tanganyika, was probably the last to be disconnected from the original inland sea, for in its waters have been lately discovered mollusca which seem to establish the fact, in Moore's opinion, that this lake was at one time part of a Jurassic sea, probably—if the Monts de Cristal were being raised at the end of the Triassic period—at a very early stage in this epoch. Stromer, however, appears to hold that Moore's contention is not supported by geological facts. The Mitwanzi Gorge is the gate in the Mitumba Mountains through which the Lukuga carries down the united waters of Kivu and Tanganyika to the Kamolondo terrace, which thus becomes the recipient of the whole body of the waters of the upper zone. Each of these lakes had a separate existence; in them were deposited some of the older rocks, and each in turn found its way by a process similar to that already alluded to, in the cases of the Albert lakes and the Niger Lake, to the stream now called the Congo.

Fergusson, G.J., 1901, xvii, p. 1, map.

B.C., 1895, p. 7.

Briart, M.G. 1892, p. 150.

M.G., 1892, p. 141.

Lemaire, M.G., 1900, p. 507.

Moore, G.J., xvii, 1901, p. 1.

M.P.G., xii, 1901.

Cameron, i, p. 305.

Stanley (1), p. 358.

38. The representatives of the older formations of this area, may, generally speaking, be divided into two groups, the one overlying the other. The lower and harder group, generally horizontal, or nearly so, rests on the denuded Archæan or the Palæozoic rocks; the upper softer group overlying the lower, but sometimes resting immediately on the primitive crust, in places where previous

denudation had laid the original rocks bare. Over the whole lies a mantle, of varying thickness, of soil, due to the chemical alteration and mechanical disintegration of the rocks. In many cases this action has taken place *in situ*, in others the disintegrated matter has been carried off and deposited elsewhere by the action of water, in mountain torrents and streams.

Summarising the results obtained by Cornet, beginning with the most recent formation and descending to the most ancient, it is found that we have, in this great Congo area, the following :— Cornet, p. 405.

5. Beds of what Cornet calls argillites, and various red sandstones, which are sometimes felspathic and always very friable. These are found only in the extreme south of the area, and do not appear in the great central basin.
4. Permo-Triassic beds divided into—
   (*a*) Upper group, the soft sandstones of the upper and middle Congo (Lubilashi beds) consisting of white and yellowish siliceous and friable sandstone, sometimes several hundred metres thick and of undulating stratification.
   (*b*) Lower group, the hard felspathic sandstones (Kundelungu beds) divided into—
      (i) Inkisi system, in which there are no traces of quartz-rock; these consist of thick, coarse, red or brown sandstones, with altered felspar, and with pebbles, especially near the base.
      (ii) Mpioka system, with traces of quartz consisting of dark red argillaceous schists, more or less micaceous, alternating with fine or medium grained compact sandstone, sometimes felspathic, and of dark red, grey or blackish colour. These beds pass under the above, lie unconformably on those below, and are gently undulating, with a slight inclination to the east.
3. Palæozoic beds—
   (*a*) In the west there are five well-marked series in the following order, from the surface downwards.
      5. Calcareous schists, with siliceous rocks (oolitic).
      4. Cherts, &c. (often oolitic).
      3. Marbles.
      2. Calcareous schists or argillaceous and calcareous schistoids.
      1. Puddingstones.

      This group may possibly be Devonian.
   (*b*) In Katanga:

      These appear to comprise puddingstones, schists, sandstones, and calcareous rocks.
2. Gneiss and crystalline schists.
1. Granite.

Barrat, B.S.G., 1896, p. 182.
Knocken-hauer, M.D.S., 1895, p. 87, map.
Tappenbeck, M.G., 1886, p. 87.
Cornet in Wauters, p. 115.

39. Along the whole western tropical coast there extends, with more or less regularity, a belt formed of beds of calcareous sandstone, either horizontal or slightly inclined, and of laterite. Immediately north of the Lukenye mouth is laterite, and just south of the Njong mouth begins the narrow coast belt of alluvial sand extending to the mouth of the Kamerun River, and backed by laterite, which reaches eastwards to the schist mountains. This laterite belt also extends both northwards and southwards from the mouth of the Congo. The calcareous sandstones are accompanied in some localities by Cretaceous and Tertiary deposits containing marine fossils. The Cretaceous belt extends from Mossamedes northwards to St. Paul de Loando and appears again at the mouths of the Congo and Gabon, and seems to be a continuation of the northern Cretaceous coast belt (section 31).

Le Chatelier, B.S.G., 1900, ii, p. 161.
Barrat (*above*).
Dupont, M.G., 1888, p. 22.
Barrat (*above*).

The tertiary deposits are found chiefly in the neighbourhood of Pointe-Noire near Loango and in the vicinity of Libreville, and appear in the form of fossiliferous Miocene calcareous deposits. Following the coastal belt, which has an average width of 100 kiloms., is the Monts de Cristal mountain region, upheaved, as already mentioned, at the end probably of the Triassic period, and made up of gniess, mica schists, and metamorphic schists, which have been greatly folded, and in which are found large veins of granite. These mountains are followed by the slightly undulating beds of schists and quartzites, with here and there calcareous masses, the whole covered by the thick formation, mentioned above, of sandstone, horizontal or nearly so, which reaches even to the summit of the mountain chains in several localities. Thus we have, throughout the length of the western coast, a littoral laterite zone, a mountain zone, and a zone of plateaux of the general style of formation given above. Barrat and Knockenhaur and Lenz account for the northern portion ; Cornet, Pechuel-Loesche, Dupont and Tappenbeck for the central part; while the Angola portion is similarly described by Choffat; and in the German sphere, to the south, the crystalline district is shown as succeeded by sandstones of the Table Mountain type and the Kalahari formation. This region of mountains and plateaux, consisting of the oldest rocks, which have been folded and contorted, once formed great ranges of mountains, which however, through countless years, have been eroded and denuded, worn down and reduced to regions of only moderate altitude.

v. Reichen-bach, map.

VI.—*South-Central and Southern Africa.*

40. When we come to South-Central and South Africa there is the same story of the inland seas and lakes, the beds of which were gradually filled with the offscourings of the adjacent higher land, and of results of volcanic action. But the history of the South brings to light one very interesting feature, namely the existence of a great Ice age during the Permian period, when Africa, Hindustan, and Australia formed one great continent. The Dwyka conglomerates were then left as the residue after the crushing and

De Lap-parent, p. 905.

crashing and grinding of the ice masses of that remote epoch, and subsequently formed the great lake basin of the Karoo formations, which are entirely of lacustrine origin.

41. A very large area of South Central Africa is covered by rocks of volcanic origin, and in these are embedded fragments of older rocks altered into schist. There is an extensive igneous area, consisting largely of "greenstone," which reaches from the Vaal River to about 60 miles beyond the Victoria Falls, on the Zambezi, and has an average breadth of 150 miles. Another igneous area, consisting of a volcanic line of hills, runs parallel with the Maseganite formation south and south-west of Lake Ngami, consisting chiefly of quartz-porphyry and greenstone. The altered rocks, which were probably originally sandstone deposited in the inland seas, stand out like islands, and the igneous matter has sent out great arms into the valleys, covering a total area of not less than 150,000 square miles. Livingstone argues that these extensive seas of lava were sub-aërial because bubbles often appear as coming out of the rock into the vitreous scum on the surface of successive flows. The great band of granite, gneiss, and schists, which has already been described as occupying an immense area in the southern portion of North Africa, after sporadic appearances in the regions adjacent to the Congo-Zambezi parting, principally in the Katanga area and the head waters of the Kassai, rises again to the surface in the tableland of Mashonaland and Matabeleland, as well as to the south of the Limpopo.

Living-stone (1), vol. ii, p. 215.

Passarge, G.J., xi, 1898, p. 181

Livingstone (*above*).

42. The underlying rocks of the South African system are generally called Primary, a name used by South African geologists to denote those non-fossiliferous rocks which belong to the lower portion of the Palæozoic period. Livingstone, however, maintains that they still sometimes contain fossil remains of the lowest order—probably Silurian—and ripple-marks, but no animal remains. These rocks are intensely folded and are covered unconformably by thick formations of the periods known as Cape (Kap) and Karoo. The gneiss appears to have generally a north to south, or north-east to south-west strike and the mountain ranges also have this general direction, *e.g.*, the mountains in the lower Orange River region, in Great Namaqualand, and in Damaraland. In the gneiss of Damaraland, and Great and Little Namaqualand, are intrusions of granite, diorite, and serpentine, &c., and among these are the copper mines. The Swazi, Malmesbury, and Namaqua beds, which are regarded by many geologists as of Silurian age, consist mostly of metamorphic clay-slate, quartzites and quartzose sandstones, and extend over large areas in the Transvaal, in Swaziland, and also in the south and south-west. These primary formations are traversed by intrusive granites, and the auriferous deposits occur throughout these beds in quartz-veins filling up the fissures of the rocks, and are, therefore, more abundant in faulted districts. The Banket formation of the Rand is quite different from this, and consists of conglomerates, so that we have, in reality, two perfectly distinct sources of gold.

Livingstone (*above*).

Schenck, M.P.G., 1888, p. 225.

Molengraaf, B.S.G., iv, 1901, p. 450.

43. Previous to the period of volcanic activity which produced the igneous rocks, or the older of them, for they are of various

Livingstone (*above*), p. 222.

ages, it is probable that the floors of the inland seas became the sites of immense deposits of sandstone and limestone, large masses of the former being found lying horizontally or only slightly inclined. And the coast lands of these seas were doubtless clad with the vegetation which forms the coal-fields of the succeeding period. These inland sea deposits form the Cape beds which lie unconformably on the folded and contorted Silurian rocks and consist chiefly of sandstones, schists (Schiefern) and limestones, mostly of marine origin. This series has been variously divided by different authorities. The exact position, in the series, of the Banket and blue-black Dolomite, is not determined. All that is absolutely known is that where they are found covered, that covering is of the Karoo formation, and that nothing underlies them but the metamorphic series, so that though the precise position is not known, the limits between which these formations must lie are fairly well determined. This Dolomite extends over a portion of the Transvaal, and is met with also beyond the borders of that colony in Griqualand West and also in Namaqualand. The Banket formation is also found outside the Transvaal area, in some localities in the Orange River Colony bordering on the Vaal River and there appear also to be traces in Zululand and in the north of Natal. The age of the Table Mountain sandstone is also at present undetermined. The formation consists chiefly of sandstones and quartzites, and is largely developed in the Huib plateau of Great Namaqualand, in the Drakensberg of the Cape Colony, in Natal and the Eastern Transvaal. The Bokkeveld formation is Devonian, and is mainly composed of quartzose sandstone. Areas of these beds are found in Great Namaqualand, the Bokkeveld Mountains in the south-west of Cape Colony, the Magaliesberg, Drakensberg and Mariko Mountains of the Transvaal. Of the Carboniferous age are the quartzites of the Zuurberg and Zwarteberg formations, which surround the Cretaceous deposits of Uitenhage and are continued westwards in a band which lies to the north of the Devonian rocks. The Cape formations are also traversed by intrusive rocks; notably by those red granites, which form the Bosch Veld of the Transvaal, and which must be carefully distinguished from the granites of the older series. It is these intrusions which have disarranged the horizontality of the Cape series.

Schenck, M.P.G., 1888, p. 227.

Gibson, p. 11.

Molengraaf (*above*).

Schenck (*above*).

Molengraaf (*above*).

44. This volcanic activity appears to have continued with increased energy throughout the Karoo age, a very large part of South Africa, the greater part of whose surface is covered by the Karoo formations, being threaded with dykes and overflowed with sheets of lava, necks and old vents being extremely common, the Kimberley diamond pipes for instance. It was during this Karoo period that the floating masses of luxuriant vegetation of the inland seas were covered and produced the coal-bearing strata. And yet these strata are mainly horizontal and not much disturbed, though slightly inclined on their southern verge. The Karoo formation forms the greater part of Cape Colony and Natal, the whole of the Orange River Colony and the south of the Transvaal. In the south and west of the Cape Colony it is surrounded by the

Gibson, p. 14.

Jones, P.G.A., iv, No. 8, 1876.

Schenck (*above*).

Zuurberg, Zwarteberg and Bokkeveld Mountains; in Griqualand West it lies alongside of the blue dolomitic limestone of Cape (Kap) formation, and in the south of the Transvaal it borders on the sandstone of the Cape (Kap) formation, while in the east of Cape Colony, between the Fish and St. John's Rivers, it reaches up to the shore of the ocean. This Karoo formation is composed mainly of hard dark blue shales, sandy schists, schistose sandstone, marl schist and sandstone with a little limestone, and is divided into an upper and a lower series, the latter comprising the Dwyika conglomerate and the Ecca beds. As had been previously pointed out by Bain, Jones, Dunn and others, Molengraaf conclusively proves that the Dwyka conglomerates are the glacial residue of the Permian age, and suggests that the Ecca beds are contemporaneous with some Australian glacial deposits of course of the same age. There is a distinct difference between the conglomerates of the Banket and Dwyka formations; for whereas such pebbles as exist in the latter are of various kinds of rocks, the pebbles of the former are almost exclusively composed of quartz. The upper Karoo series lies almost horizontally on the lower series, is of lacustrine origin, and was formed after the close of the Permian glacial epoch. This series includes the Beaufort beds and the Stormberg beds. The former consist largely of red and greenish shales, with sandy shales and sandstone, the latter light coloured, and red sandstone, with which are associated thick deposits of coal. These coal deposits seem to be almost exclusively confined to the Stormberg series.

Jones, M.J., 3/7/86.

Molengraaf, B.S.G., iv, 1901, p. 450.

Gibson, p. 9.

Molengraaf (*above*).

45. A very large area including the Kalahari region and that lying to the east of it, the Kalahari and Limpopo plateaux having once formed a single region inclining from east to west, is covered with what Livingstone thought was the outpouring of lime water from the bowels of the earth or calcareous tufa, but which in reality is a derivative of the lime-felspar of igneous and Palæozoic rocks. Of the great inland lakes, one found an outlet in the gorge which which was created by the rupture, which formed the Victoria Falls, and similarly the rent at Aughrabies Falls formed an outlet for the waters of the Orange Lake, and thus prepared the way for the formation of the present Orange River, which, before the capture of this source of supply, was, doubtless, a stream with many feeders from the Namaqualand and Drakensberg plateaux in north and then curving round to the west. The ancient river system appears to have had a huge main artery extending from the source of the Zambezi through the Barotse Lake and continued southward to the Orange. Previous, however, to this state of things, there is conclusive evidence of the existence of very great fluvial activity, producing extensive and enormously thick beds of well-rounded shingle and gravel. Instances of this occur in connection with the bed of the Loangwa River, which was evidently the site of a former lake. Here the banks exhibit great beds of rounded shingle 60 feet thick, and again similar beds, with hard crystalline pebbles, occur above the Kebrabassa Rapids on the Zambezi. The area covered by the Karoo formation is a question of great importance, inasmuch as the existence of coal depends

Livingstone (1), vol. ii, p. 215. Laloy, B.S.G., iv 1901, p. 270.

Choffat, Portugal em Africa, vii, 1900, No. 83, p. 529.

Livingstone (*above*), p. 219.

De Lapparent, p. 905.

Gibson, p. 13.

Jones, M.J. 4/12/86.

upon the presence of these beds. De Lapparent gives them a very wide extension, maintaining that the Karoo formation covers the whole central part of Africa, extending even beyond the 10th degree of North Latitude. This would place the Congo series among the Karoo beds. Gibson, on the other hand, points out that, north of Lake Bangweolo, there is no direct evidence of the existence of strata of Karoo age, the area, over which such strata have been identified, being limited by the 5th and 33rd parallels of South Latitude. It is interesting to note that the coal occurring, as it does, in detached patches, points to its being laid down frequently in great pools.

THE NOTES.

[*The numbers prefixed to the* NOTES *refer to the corresponding numbers on the reference map.*]

1. The whole of the tableland lying in front of the Atlas is tertiary, consisting of soft sandstone and red clay with porous limestone and conglomerate.
   (Fischer, V.G.E., 1899, p. 204.)
2. The soil of the Nyasa-Tanganyika plateau is disintegrated granite. (See No. 236.)
   (Boileau, G.J., xiii, 1899, p. 577.)
   From Karonga to the top of the plateau, north-west, we have the alluvium of the lake shores, followed by Triassic beds, which are succeeded in turn by sandstones and conglomerates, the top of the plateau being of granite and gneiss.
   (Moore, G.J., x, 1897, p. 296.)
3. The Fisa Mountains are sandstone (*ibid.*).
4. The granite and quartzite of the Latuka Mountains, with red clay in the valleys, alternating with sand.
   (Stuhlmann, p. 171; and S.G.M., 1899, p. 61.)
5. The Bahr-el-Ghazal region is laterite, with gneiss detritus and granite-crowned hills. (See No. 148.)
   (Junker, ii, p. 145; and S.G.M., 1899, p. 63.)
6. The A-Zande plateaux have a gneiss subsoil, relatively friable, levelled slightly by the action of water, and then covered with more recent beds of poor soil (laterite), clay, sandstone, ferruginous conglomerate, humus and marsh deposits, reaching from the Upper Sue River to Darfur, and Wadai.
   (Cureau, M.G., 1897, p. 600; B.S.G., iv, 1901, p. 268; S.G.M., 1899, see No. 5 *above*.) (See No. 307.)
7. Jebel Mangayat and the adjacent heights are of granite, so also are the valleys of the Sue River and the tributaries of the Bahr-el-Arab.
   (Cureau, M.G., 1897, p. 600; and S.G.M., 1899, see No. 5 *above*.)
8. Jebel Marrah, in Darfur, is a series of volcanic peaks rising out of a granite plateau, while to the south of 12° N. is stoneless alluvium (clay and vegetable soil).
   (Mason Bey, M.P.G., 1880, p. 377; and S.G.M., see No. 5 *above*.)
9. North of Darfur are numerous summits forming valleys with very slight slopes, where the stony and sandy soil soon soaks up the water.
   (S.G.M., see No. 5 *above*.)

10. The soil of Kordofan is granite sand mixed with clay, the plateau being crowned with granite blocks. Farther south, in Dar Nuba, are wide areas of forest country with a soil of rich black mould.
(Marno, p. 198; and S.G.M., 1899, see No. 5 *above*.)

11. North Angoniland is granite and quartz.
(Angus, S.G.M., 1899, p. 79.)

12. At the Devil's Gorge (Zambezi) are high walls of rock, surmounted by huge blocks of basalt.
(Gibbons, G.J., 1899, xiv, p. 93.)

13. The southern part of Nyasa is surrounded by granite mountains.
(G.J., x, 1897, p. 298.)

14. The desert south-east of Korosko consists of quartz-porphyry, granite, gneiss, amphibolite, diabase, gabbro and quartz-diorite.
(Qr. J. of Geology, 1897, p. 360.)

15. On the banks of the Mungo River are deposits of lower Cretaceous age.
(Abhandlungen, Gesellschaft d. Wissenschaft. zu Göttengen, 1898, pp. 51–56.)

16. The Igharghar Basin is of cretaceous formation, and in the south-east Devonian and Carboniferous (mountain limestone).
(Mem. Soc. Ing. civ. de France, Paris, 1897, pp. 1–11.)

17, 18. Behind the Somali coast belt lie two Cretaceous ranges and one of Archæan rocks.
(Geolog. Mag., 1896, p. 289.)

South of Guban is a vast block of Archæan rocks, gneiss, amphibolite, &c.

The more rugged peaks of the coastal belt are Archæan outliers.

Dalmoli is Archæan, Negegr Plateau is limestone, while Habrje consists of granite.

South of Dalmoli is Cretaceous lime, followed further south by Archæan rocks.

Burao district is also Archæan, as well as Faradairo.

Guban is composed of lime, Artalla Range is Turonian over Neocomian, Bur Dap is Neocomian, and God-la-Yare district is limestone (see No. 257). The Somali limestone is of different ages.
(Gregory, Qr. J. of Geology, 1900, p. 26.)

The Bihen limestone is lower Oolitic or Bathonian.
(Gregory, G.J., xi, 1898, p. 37.)

19. *Table Mountain sandstone.
(Report of Geolog. Commission for the Cape, 1897, p. 52.)

20. The Karoo with Beaufort West, Karoo formation (*ibid.*).
(See No. 42.)

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* Table Mountain sandstone consists of sandstones and quartzites with occasional shales.—(S.G.M., 1899, p. 432.)

21. Worcester, Tulbagh, &c., and Malmesbury, *Malmesbury schist (*ibid.*).
22. Zwarteberg, quartzite and schist (*ibid.*).
23. The dunes of W. Erg abut on a Cretaceous escarpment at El Golea.

(Flamand, A.G., 1899, p. 231.)

24. W. Erg is composed of sand dunes (*ibid.*).
25. The district from Wargla to Tuggurt consists of Quaternary alluvium.

(S.G.M., 1899, p. 373.)

26. Sandstone and red sand.

(V.G.E., 1899, p. 189.)

27. The bed of the Gofka, near Brava, is of dark grey alluvium.

(S.G.M., 1899, p. 378.)

28. Between Tadent and Asiu wells is gravel, with large blocks of granite here and there.

(S.G., 1899, p. 219.)

29. Archaic crystalline, micaceous quartzites and mica schist.

(Cornet, p. 406.)

30. Schists and gneiss (*ibid.*).
31. Calcareous schist (*ibid.*).
32. Hard felspathic sandstone (*ibid.*).
33. Soft sandstone (*ibid.*).
34. Hakansson, Bia and Nzilo Mountains consist of granite and gneiss.

(Cornet in Wauters, p. 115.)

35. From the Upper Sanga River to the Nile, below Lake Albert, granite and crystalline schists (*ibid.*).

(For Bangi River portion, see also Julien, B.S.G., iv, 1901, p. 130.)

36. Hard felspathic sandstone overlying granite and gneiss (*ibid.*).
37. The districts of Katanga, of the upper courses of the Lualaba, Lufila and Luapula, are pre-Cambrian, Cambrian and Silurian with Devonian (*ibid.*)

At Juo Falls, in Lufila River, are horizontal beds of sandstone.

(Delcommune, M.G., 1900, p. 181.)

38. Old non-crystalline rocks occur between the Ubangi and the Congo.

(Cornet in Wauters, see No. 34 *above*.)

39. Kundelungu and Manika Plateaux, the Lower Luemba River district, both sides of Tanganyika, the Malagarasi basin and the district from Stanley Falls to Nyangwe are hard felspathic sandstone. The same formation is also found on the Ubangi, the Upper Kwango, the upper western tributaries of the Kassai, on the Upper Ogowe and Benue, and the lower Niger (*ibid.*).

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* The Malmesbury beds consist of non-fossiliferous slates, phyllites, mica schists and quartzites, with intrusive granite, quartz-porphyry and diabase (S.G.M., 1899, p. 432).

40. The soft sandstone of Lubilashe forms the soil of all the central part of the Congo basin (frequently covered by alluvial deposits) and of the Sankuru. South of 5° 30′ S. it is found mixed with clays and hard sandstones (*ibid.*).
41. North of Mount Elgon are granites and schists, and further north sandstone and Kemkis lime.

(T., 21/6/99, p. 4.)

42. The north-east of Cape Colony above 32° S., and to the east of 24° E., and the western part of the Orange Free State are the Karoo formation (Trias).

Basutoland and the adjoining part of the Orange Free State, with the western portion of Natal, belong to the coal-bearing series.

The northern part of the Orange Free State, and the extreme East of the Transvaal are formed of various sedimentary rocks, dolomites, sandstones, &c.

The eastern part of Natal—diorite and old red sandstones alternating towards the coast, with crystalline schists.

The central and northern parts of the Transvaal are very complex—old red sandstone, diorite, gneiss, &c.

Matabeleland is also complex—crystalline schists, granites, diorites, sandstone, &c.

(M.P.G., 1884, p. 441, map.)

43. In German East Africa the coast region consists of the newer formations, coral rock and sandstone, with alluvial accumulations.

(For the coral and alluvium in the neighbourhood of Dar-es-Salam, see also Werth's map in Z.G.E., 1901, p. 152.)

Unyamwezi and the district south to the Ruaha River is granite.

On both sides of the middle of Tanganyika (see Nos. 36, 39) red sandstones are found.

In German South-West Africa, in Hereroland, is an extensive crystalline district, which in the interior is covered by Table Mountain and Kalahari sandstone.

Nama strata and sandstone extend south into Namaland.

In Kamerun are extensive basalt mountains (Kamerun Mountains, and northwards). This formation is also found on the Upper Benue and in Adamawa. *Note.*—The Benue sandstone contains no fossils.

("Die Geologie der Deutschen Schutzgebiete in Afrika," E. S. von Reichenbach, Munich, 1896, *with 3 maps.*)

44. Kikuyu is a gneiss district.

(Gregory, G.J., 1894, vol. iv, p. 289.)

45. Kenia and Kilimanjaro, lavas and agglomerates (*ibid.*).
46. The coast region of British East Africa is made up of coral rock and cemented coral sand, covered by sand dunes, raised beaches, and a red soil of wind-borne quartzose sand (*ibid.*).

47. The foot-plain, inland from the coast region, is composed of Jurassic shales and sandstones, with some beds of limestone (*ibid.*).

48. The Nyika, or second plateau from the coast, consists of sandy steppes with red quartzose sand (*ibid.*).

The boundary between the metamorphic and sedimentary rocks runs a little west of Kilibasi. The Taro Steppe is of sandstone.

(Hobley, G.J., 1895, vol. v, p. 556.)

49. Burra (Bura) and Teita Mountains, the hills on the Kikumbulu Plain and to the west of Ndangi River, also the Iveti Mountains, Ithamba, Voroni and Changabubu Ranges, on the south margin of Kikuyu, with Lorogi Mountains and General Matthew's Range are gneiss.

(Gregory, G.J., 1894, vol. iv, p. 289.)

50. The volcanic mountain zone containing Kilimanjaro, Theuka, Kyulu and Kenia, and reaching north as far as Kulali Mountain, on the east of Lake Rudolf, is eruptive (*ibid.*).

51. The Rangatan or high inland plateau, including the Kapte Plains, and a tract running north from Kilimanjaro, including the Athi Plains and ending in the hill land to the east of Kikuyu, consist of rich lava soil; so, too, do the eastern slopes of Lake Victoria (*ibid.*).

52. The Graben or great Rift Valley consists of alluvial and pleistocene sandy plains with volcanic craters and lava (*ibid.*).

53. The plateau of Porto Novo, Alada and Dobo are composed of argillaceous and arenaceous stratified beds resting on rock whose nature is as yet unknown.

(D'Albeca, B.S.G., 1895, p. 183.)

Lower Dahome, *i.e.*, the portion south of 9° N., is divided into two zones. The first is covered with sand to a depth of 2 metres, over which is vegetable humus. On the banks of the lagoons and streams the sand is mixed with alluvium. In the second or more northerly division the sand is replaced by clay to a depth of 5 or 6 metres. Not a pebble within 100 kiloms. of coast.

(Brunet, p. 27.)

54. The Mahi region and the Save district consist of granites surmounted by ferruginous conglomerates.

(D'Albeca, B.S.G., 1895, p. 183.)

55. Further north the mountains are quartz and red sandstone, with intercalations of trap rocks, diorites and porphyries.

(D'Albeca, B.S.G., 1895, p. 183.)

In Upper Dahome, north of 9° N., the soil is vegetable humus, below which are sand and calcareous rock and argillaceous sedimentary rocks, with traces of porphyries, quartz, &c.

(Brunet, p. 27.)

56. North-east of Mossi is a plateau surmounted by table mountains of sandstone and shales.

(Monteil, A.G., 1895–96, p. 212 (Bibliog.).)

57. Uli Plateaux are ferruginous, and the Sandugu and Kalonkadugu Steppes are formed of compact clay.
West of Kontor lie wooded laterite hills.
(Rançon, "Dans la Haute Gambie," Paris, 1894, pp. 50, 60, 102, 147, 167, 186, 206, 226, 260, 290, 312, 351, 372, 419, 435, 480, 534.)

58. In French Congo the coast belt consists of a plain of sand and laterite with calcareous traces.
Then a band of older schists, Silurian and Devonian.
Then horizontal beds of red sandstone surmounted by white sandstone (? trias) which seem to correspond with the red and white sandstones of Katanga. (See No. 61.)
(Barrat, "Sur la géologie du Congo français," Ann. Mines, vii, 1895, p. 487.)

59. Between the bend of the Ogowe River at Lastourville and Samba, on the Ngunie, are the older schists of the Monts de Cristal.
(Bertou, B.S.G., 1895, p. 211.)

60. Between Sesheke and Lialui the country is composed of sand belts and large open vleis.
(Harding, Report on Administration of Rhodesia, 1898–1900, p. 99.)

61. First a coast zone, then the Monts de Cristal, whose folds are generally parallel with the coast, and then the horizontal formation of red and grey sandstone. (See Nos. 29 to 32 and 58.)
(Bertrand, "La géologie du bassin du Niari," Revue générale des Sciences pures et appliquées, v, 1894, p. 792.)

62. Angola is made up of four geological regions—
(1) The region of soft sandstone similar to the great Congo basin. (See No. 40.)
(2) The region of hard sandstone. (See No. 39.)
(3) The schist region of the Monts de Cristal. (See Nos. 31, 58 and 60.)
(4) A coast belt.
(Choffat, Revista de Sciencias Naturaes, 1895, iv, No. 1.)

63. From the Tana River westwards is a medley of metamorphic rocks of all kinds.
(G.J., 1894, vol. iv, p. 122.)

64. In the south-east of Sierra Leone the Mandi Mountain district is quartz, but further on the Bandi country consists of dark grey granite.
(Alldridge, G.J., vol. iv, 1894, p. 129.)

65. Between Chimoio and Christmas Pass Range is gneiss and granite, but the formation changes on reaching the mountains, which are composed of metamorphic rocks superimposed on a granite base.
The soil of the Umtali-Salisbury Plateau is decomposed granite.
Along the railway route the structure is very uniform—almost entirely granite, with occasional dykes of greenstone.

Salisbury Kopje is of magnetic ironstone shale.

A belt of metamorphic gold-bearing rocks extends east and west from Umtali.

(Eckersley, G.J., 1895, vol. v, p. 34.)

66. In Adamawa, from Garua northwards to Marua and the Mandara Range, is an undulating gneiss region, above which rise massive granite ridges. The Mandara Range is a northern continuation of the volcanic line through Fernando Po and Kamerun Mountains.

Ngaundere lies at the foot of a granite range.

(Passarge, G.J., 1895, vol. v, p. 50.)

67. The Ait Robaa district of the Atlas is composed of grey and black shales with beds of quartzite.

The Atlas, east of Marocco, are quartzite overlying grey and black shales.

Between the Atlas and the anti-Atlas is gravel with stone-strewn sand.

The southern slopes of the Atlas are of limestone.

The anti-Atlas are volcanic.

(Harris, G.J., 1895, vol. v, p. 321.)

68. To the north-east of Nyasa the Livingstone or Kinga Range is of ancient crystalline rocks—quartzite, horneblende, magnetite. The crater lake region is volcanic.

(Kerr-Cross, G.J., 1895, vol. v, p. 114.)

Bornhardt says that north of the Ruhuhu River, *i.e.*, Livingstone Range, is gneiss, and south granite.

(G.J., xv, 1900, p. 421.)

69. The shores of Lake Kivu consist of lava.

(Von Götzen, G.J., 1895, p. 359.)

70. Between Shoa and Kaffa the geological constitution of the country is decidedly volcanic, with iron here and there, especially near Fin-Finni and Gera.

(Cecchi, M.P.G., 1886, p. 309.)

71. South-west of Abu Roash is upper Cretaceous; the Pyramid district and Whitehouse Hills are upper Eocene strata.

(Schweinfurth, M.P.G., 1889, p. 1.)

72. The Nyika Steppe is continued south of the Umba River. (See No. 48.)

(Baumann, M.P.G., 1889, p. 41.)

73. The Usambara Mountains are crystalline schists (*ibid.*).

74. Between 8° 30′ N. and 10° N., and 37° E. and 39° 15′ E., the portions of the country which are higher than about 2,400 metres are chiefly porphyry. These overlie red standstone, whilst the lowest parts are red sandstone and shales.

(A. Steckers, M.P.G., 1891, p. 233.)

75. In Zaghuan the upper beds are Tithonian, the lower Oxford, and under this is a calcareous formation; further south-west is upper Cretaceous, and thence north-west to Suk and Jemaa is an Eocene tract. Zanfur, Massuge, Mahiza, &c., are upper Cretaceous, and Cape Bon Peninsula, Pliocene Miocene and Quaternary.

(Le Mesle, "Note sur la Géologie de la Tunisie," B.S. Géolog. de France, 1890, pp. 209–219.)

76. The mountains running parallel with the Red Sea, between the coast plain and Keren, Asmara and Adua, are of the old crystalline group; the boundary between the plain and the mountains eruptive, and a great part of the plateau much older eruptive.

(Baldacci, "Osservazioni fatte nella Colonia Eritrea, Memorie della Carta geologica d'Italia," vol. vi, Rome, 1891.)

77. The whole region comprised between about 1° E. and 14° E., and the 27th and 35th parallels consists of a huge crust of calcareous formation (middle and upper chalk age and green sand).

(Choisy, "Documents relatifs à la mission dirigée au sud de l'Algérie," 2 vols., Paris, 1890, and De Lapparent, p. 1201.)

78. The commonest formation in British Central Africa is a mixture of metamorphic rocks, clay-slates, gneiss and schists, *e.g.*, over much of the country between Nyasa and Luapula River, in parts of the Shire Highlands, and north of Zambezi River.

The valleys of the Shire, Chambezi, Luangwa and other large rivers have an upper alluvial stratum.

The principal mountain ranges are mostly granite or its product, red ferruginous clay (much of Shire Highlands).

There is a sandstone outcrop north-west and north-east of Nyasa (Mount Waller and the hills of Amelia Bay); also a little way back from the north end of the lake, in German territory; to the west of the Shire, near the Portuguese boundary; at the south end of Tanganyika; all round Lake Mweru; and in the countries adjoining the Luapula River.

Volcanic lavas and tuffs appear on the Upper Mlanje Plateau and at the north end of Nyasa.

Quartz is plentiful in the mountains west of Nyasa and in parts of the Shire Highlands.

The low flat hills of the Upper Shire district are marble.

(Johnston, "British Central Africa," 1897, p. 47.)

North of Nkata Bay and on the opposite side of the lake at Amelia Bay are masses of red sandstone cliffs wedged between and lying upon granite and gneiss.

(Moore, G.J., 1897, vol. x, p. 292.)

79. Chiefly mica schist, with old granitic eruptive rocks.

(Stuhlmann, M.P.G., 1892, p. 144.)

80. From Konakri to Frigiabe the formation is sandstone, with vast collections of eroded humus in the valleys.

Kinsam Mountain region is granite overlaid by standstone and laterite.

The Diagissa Plateau is laterite. The northern abrupt range is granite.

(Maclaud, La Politique Coloniale, 18/8/99.)

81. In Sierra Leone there is a small alluvial coast zone, followed by hills and the plateaux of Talla and Falaba, with

crystalline base partly covered by horizontal beds of sandstone, which greatly resembles the Nubian formation, or by dolerite (on the Talla Plateau). There is a covering of laterite up to the altitude of 1,000 feet.

(Scott-Elliot, Report on the Geology of Sierra Leone, Parliamentary Paper, C. 6998.)

82. In French Congo there is granite on the surface at Lambarene, 200 kiloms. from mouth of Ogowe River. Granite, too, forms the mass of the Monts de Cristal, north of Njole. The Ogowe also passes two other granite masses in Okanda district, and granite appears again at Lastourville. Above the granite is a series of palæozoic rocks, many of them metamorphic.

(Barrat, "Sur la géologie du Congo français." Comptes rendus de l'Académie des Sciences, 1894, vol. cxix.)

83. Fossils found at Mtaru (on the Pangani River) and in Tanga and Saadani districts, show that the formation is Jurassic, and resembles that of Kutch in India.

(Futterer, "Beitrage zur Kenntniss des Jura in Ostafrika," Zeitschr. Geolog. Gesellschaft, 1893, xlvi.)

84. Between the Rivers Mambere and Wom is a succession of sandstone plateaux, without fossils, with substratum of crystalline rocks, generally folded. The horizontal beds of sandstone, often ferruginous, friable on the surface, and reduced to sand, appear at all altitudes from 500 to 750 metres. The crystalline substratum sometimes emerges and forms chains of mountains, especially towards the Wom, near which are also schists, like those of the Ogowe.

(Herr, of the Clozel Mission, A.G., 1895–96, p. 318.)

85. That portion of Baule north of 6° 30′, between the Bandama River on the west, and Tumodi and Kodiokofi on the east, has a vegetable soil, covering ferruginous conglomerates.

(Eysseric, R.G., 1889, p. 198.)

86. Behind the sandy coast belt, which is from 15 to 30 kiloms. broad, extends a plateau of gneiss.

(Hauser, Q.D., 1899, p. 76.)

87. In German East Africa, behind the Tertiary and Cretaceous coast belt, lies a series of crystalline mountain masses extending from Kilimanjaro to Pangani, followed further inland by the zone of dislocation and volcanic action (the E. Graben, or Great Rift zone). (See No. 52.)

Crystalline schists form the backbone of the mountains enclosing the Western Graben.

(Baumann, "Durch Massailand zur Nilquelle." Berlin, 1894, Part II, pp. 133–260.)

88. In South Shashi the prevailing rock is a reddish granite or gneiss; further north are ferruginous schists; east of Ntussu are similar schists with quartz and diabase, forming continuous ranges; west of Lake Eyassi is an unbroken zone of gneiss.

(Dr. Dentz, D.K.Z., 1/6/99.)

89. The coast belt to the east of Jub River, extending as far inland as Derausale, is composed of Quaternary and recent formations; so, too, is the district of the Lower Omo River.

The Upper Omo region and the district around Lake Pagade (Regina Margherita) is of recent volcanic formation (basalt, andesite, trachite and liparite).

Of the same formation is the tract lying to the east of Lake Stefanie, called Tertale.

Between the northern parts of Lakes Rudolf and Stefanie is gneiss; and also a district extending from Burgi as far south as 4° N.

The regions to the south of Lugh, and both east and west of Sankurar, are of marine calcareous formation.

To the north and west of Lugh is a large area of gypseous formation.

Succeeding the coast belt to the east of the Jub River, and reaching north as far as Dusta are older rocks, diorite, syenite and granite; there is a similar tract to the west of Salole on the Daua.

(Sacchi in "L'Omo," by Vannutelli and Citerni. Milan, 1899.)

90. A large triangular shaped tract, with base extending along the south-eastern shores of Lake Victoria, and with apex about 100 kiloms. north of Nyasa, is granite.

This is entirely surrounded by gneiss and schists, extending to the north of Lake Victoria, on both sides, and including the Western Graben.

Behind the coast belt, which is composed of recent deposits, coral, alluvium, sandstone, &c., is carboniferous formation, which between lat. 7° S. and 10° S. projects in a south-westerly direction towards Nyasa.

In Uganda there is a narrow belt of conglomerate extending along the north shores of Lake Victoria from Katonga Mouth to Murchison Bay (and including the Sesse Islands), followed further north by granite, reaching to Lake Choga (Chioga).

(Peters, "Das Deutsch-Ostafrikanische Schutzgebiets," map.)

After crossing the Nandi Range, one enters the Nyanza region, which consist of gneiss or granite, usually in small lumpy hills. This region embraces Kavirondo, Usoga and Uganda, as well as a large part of Ankole, and appears to reach right to the base of Ruenzori. North-West Ankole and most of Karagwe consist of a series of schists, folded over and over, at a very steep dip and with an average strike of N.N.W. These overlie the gneiss of the Uganda Plateau.

(Scott-Elliot, G.J., 1895, vol, vi, p. 302.)

91. South of the Umvoti River, the Noodsberg form the longest stretch of Silurian sandstone in South Africa.

(Ingram, "The Colony of Natal," 1895, p. 8.)

92. This whole region is made up of limestone and sandstone. South from Gatron is a stony waste, with limestones and sandstones intermingled.

Afafi is of limestone with blackish sand overlying it in places.

South of Gurna is sandstone, and then sand and gravel.

The region of the Tollubu is lime.

Tusidde, the highest of the Tibesti Mountain mass, is of lime; and so also is the backbone of the whole system.

The mass of Merda Sodoing is sandstone overlying limestone, from which basalt frequently protrudes.

The Kinsuing Hills are of limestone and clay.

North-east of the Dommado are blocks of basalt and sandstone, overlying a porous formation (dolomite), which is here the prevailing formation, with (further north-east) a thick overlying stratum of limestone.

(Nachtigal, M.P.G., 1870, pp. 25, 47.)

93. The Shebka of Mzab is a plateau of dolomite bounded on the north by Wads Besbaier and Settafe and a line through Haniet and Lekaz. On the south it extends as far as El Hadadra and Wad Zirara, and on the west to Wad Lua; while on the east it penetrates between the Wads Zejur, Nena Mzab and Mettitli. This plateau passes insensibly into the Quaternary sand on the north, east and south.

The plateau of El Golea is of chalky calcareous rocks and passes insensibly into the above.

Between the Shebka of Mzab and Wargla is a lofty chalk plateau.

(Vine and Jacobs in Huguet, "Dans le Sud Algérien"; B.S.G., 1899, p. 285.)

94. On both sides of the Orange River, from Aughrabies Falls to the mouth, is a gneiss formation, with granite here and there.

(T. Rehbock, D.K.Z., 1899, p. 395.)

95. The coast belt from Casablanca to Wad Tensift is tertiary shell sand.

South of the Tensift, including Jebel Hadad, consists of cretaceous limestones and shales.

Shiedma Plain is covered with a hard crust formed by the cementing of the cretaceous particles.

Bled Hummel, as far east as Lake Zima, is of red and purple cretaceous shales.

Bled Hummel, to the east of Lake Zima, and the district of Rahamma, consists of friable clay slates.

From Demnat south-west to Wad Nifis, a dyke of basalt protrudes from the limestone and shales, at the merging of the mountains in the plain.

The mass of the lower ranges is composed of limestones and shales.

Above Iminifiri the anticlines are cretaceous limestone rock, and the synclines, or hollows, of shales and sandstones.

Limestone peaks and parallel ridges, with red and purple shales in the hollows, form the central mass of the Atlas.

Further west in the district of Gundafi, on the east of Wad Amsmiz, the outer terraces are metamorphic slates, broken by intrusive arms of porphyries.

On the west of Wad Amsmiz is a capping of compact limestone and sandstone.

In the western tail of the Atlas, cretaceous sandstones are thrown up on the flanks.

(J. Thomson, P.R.G.S., 1889, p. 1.)

The lofty plain on which Marrakesh stands, 300 kiloms. by 30 or 40 kiloms., consists of glacial diluvium.

(Fischer: V.G.E., 1899, p. 204–208; M.P.G., 1899, p. 151–152.)

Thomson, however, though he passed over this plain, did not notice any glaciation till he reached Titula.

(J. Thomson, "Travels in the Atlas and South Marocco," 1889, p. 210.)

96. Coral rock extends over the whole Lower Jub Plain.

The Mibungo-Kigungo district (0° 52′ N. about) is clay with red sand.

Limestone first appears near Saloli, a little south of 1° 30′ N., and is the principal rock of the country further north.

Basalt and lava also occur, with the limestone, between Seranli and Lugh.

(Jenner, G.J., vol. xiv, 1899, p. 637.)

97. The Bago River district is chiefly gneiss, with granite peaks, and traces of later volcanic rocks.

South-west from above is Kaboland, which is also gneiss;

Still further south-west Basosiland is basalt.

(Coureau, M.D.S., 1899, pp. 201, 211.)

98. The neighbourhood of Kubes is granite, whence sand and water-worn material extend south-west through Kanbis and Ennies.

The mountains at the intersection of 24° 30′ S. with 16° E. are sandstone.

(Fleck, M.P.G., 1899, p. 281.)

99. The valleys of the streams in this region (Lungwebungu River, Kwito River, Upper Kwando River, &c.) are bounded by undulations of white sand which diminish in height in the direction of the Zambezi.

(Gibbons, G.J., xv, 1900, p. 64.)

The head waters of the Okovango and Chobe or Kwando drain a country of sandhills, which rest on an extensive bed of clay.

(F. S. Arnot, G.J., 1900, xv, p. 291.)

100. In French Guinea the district of the upper coast streams, the water parting between this district and the Niger, and the whole of this part of the Niger basin, are granitic. Large areas of this are covered with either a vegetable humus or laterite. Where not so covered the granite underlies narrow bands of crystalline schists, over which are found white and grey sandstone, probably Triassic, and forming plateaux, like the Abyssinian "Ambas," with precipitous sides.

Futa Jallon is surrounded by a granite rampart of mountains.
(Salesses, B.S.G., 1899, p. 384.)

101. In the south-west and south of Cape Colony the mountains of the Bokkeveld and the Zwarteberge consist of sandstone and shales, overlying granite and the older schists. The Karoo formation, consisting of shales, and sandstone and such eruptive rocks as Diabase, extends not only over the Karoo proper, but also over the east and north of Cape Colony, Griqualand West, almost the whole of the Orange Free State, the Southern portion of the Transvaal, Basutoland, Kaffraria with portions of Natal and Zululand. The Lebompo Range running north to south between 24° and 28° S., between Portuguese territory and the Transvaal, is of porphyry; while the country west of the range is sometimes granite, sometimes the older schists and quartzites.
(Schenck, V.G.E., 1900, p. 60.)

102. North of Mount Waller (W. Nyasa), the Chitimba, Hara and Fulirwa Plains all give indications of the presence of lime, and, in the last-named, workable limestone has been found at the head of the Hungerawi stream in beds 8 and 10 feet thick, overlying a soft pinkish sandstone. In the northern section of Tumbuka Plateau the sub-soil is mostly bright red clay, very sparsely intermingled with sand and pebbles.
(J. Henderson, S.G.M., 1900, p. 82.)

103. The hills around Beni Uled are limestone, capped with granite, lava, &c. The Niffud Hills are the same, and also those of Wadi Bonjem (Bu Njem), with chalk hills and gypsum (p. xv, note).
Jebel Assud Range (J. es Soda) and the plains between Sokna and Murzuk are basalt everlying limestone (p. xxviii, *sq.*).
West of Murzuk is a plain of sand, strewn with fragments of calcareous crust, the hills being of sandstone interstratified with blue and white clay (p. xliii, *sq.*).
Still further west are sand hills with gravelly valleys and calcareous crust.
To the west of Wadi Elfu the hills are of sandstone and claystone, and so are the Ludinat Mountains and as far as Ghraat (Ghat).
South of Murzuk is sand covered with salt.
In Gatron neighbourhood are sand hills, and the plains are strewn with fragments of sandstone.
Near Meshru are low conical rugged hills to the east, the summits of which are a dark sandstone, overlying clay-ironstone, under which is white sandstone (p. 8).
The country extending from El Garha to El Wahr has a sandy surface, but there are hills with cones and peaks of sandstone, which resembles basalt in appearance.
South of this is sand and gravel.
South of Mafras Wells is limestone.
At Tigrinduma is sandstone, and at Anetraduma sand and gravel (map).

In Bilma region is red sandstone (p. 24).
South of Zo (Sau) Wells is loose sand (map).
The desert of Tintuma is fine sand.
South of Chad Lake the whole country is covered with alluvial soil, which has a dark clayey appearance (p. 108).
At Delo the country is made up of decomposed granite.
In Moira (Mandara) region the mountains are granite with quartzose and horneblende (pp. 131, 144).
The neighbourhood of Kuka is alluvial and flat (p. 150).
To the west of Chad Lake, the Katagum hill country (in Yakoba), is limestone (Part II, p. 28), though the immediate neighbourhood of the lake is soft alluvial clay (Part II, p. 35).
West of Zangeia are granite hills, the general soil being a strong red clay, with large blocks of granite (Part II, p. 36, *sq.*).
In the Kano district the soil is tough clay mixed with gravel, the stones of which are clay-ironstone (Part II, p. 40).
North of Kano is argillaceous limestone mixed with pebbles and soft marl (Part II, p. 50).
West of Kano the country is thickly wooded, with ridges of white quartz running north to south (Part II, p. 68).
West of Kandania are red and white clays mixed with gravel and traversed by ridges of schist (Part II, p. 69).
In the neighbourhood of Geoza, Reta, Birshi and Kagaria are granite ridges and huge blocks of granite (Part II, pp. 70–72).
West of Kagaria the soil is clay and gravel, with granite and mica-schist in the hollows (Part II, p. 72).
Near Lake Gondami the soil is gravelly, the pebbles being clay-ironstone (Part II, p. 79).
West of this are gravel ridges with clay on the surface (Part II, p. 80).
Near Sokoto the soil is red clay and gravel.

("Narrative of Travels and Discoveries in Northern and Central Africa," by Major D. Denham and Captain H. Clapperton, London, 1826.)

Borgu is formed of grey granite, alternating or appearing simultaneously with the copper-coloured, honeycombed lava (?) or ironstone, which forms the prevailing feature of West Africa.

(Lugard, G.J., 1895, vol. vi, p. 214.)

104. In Southern Rhodesia, between Nyamandhlovo and the Deka River is deep sand.

(A. Lawley, Reports of the Administration of Rhodesia, 1897–98, p. 365.)

105. In Northern Rhodesia, the Mashikolumbwe country, from the south-west border to the Kafukwe River, is mainly composed of red sandstone, covered with loose red and white sand (see Note 200).

Crossing at Pickering's Mission, and going north of the Kafukwe River, the country rapidly rises with

granite as far as Sakariatorubwe and eastward to Myama.

(W. Lewis, *ibid.*, p. 375.)

The low veldt of the Western Umtali (Manika) district has few mountains, but is dotted with granite kopjes; otherwise the soil is sandy.

(T B. Hulley, p. 379, Reports of the Administration of Rhodesia, 1897–98.)

106. In the Tuli district the country between the Umzingwani and Imgwezi Rivers is chiefly sandstone, with shales here and there.

(R. K. Southwood, *ibid.*, p. 198, map.)

107. In Rhodesia, the northern portion of Bulawayo district consists of micaceous slates, talcose, chloritic and dioritic crystalline schists.

The south-east portion of strongly defined micaceous slates.

On the north-west portion is found Silurian and Devonian limestone.

Bubi district consists of metamorphic slates and talcose schists.

Wankie district is carboniferous and in the north-west are intrusive dykes of basalt.

Bulalima district: granite with small belts of ferruginous schists and slates.

Mangwe district: micaceous slates, granite and gneiss.

Gwanda district: talcose slate and layers of soft potstone and steatite.

Belingwe district: talcose and chloritic schists and metamorphic slates.

Filabusi district: metamorphic slates, crystalline and talcose schists.

Insiza district: chloritic, talcose and dioritic schists with greenstone dykes.

(N. MacGlashan, British South Africa Company's Report, 1896–97, p. 82.)

108. The great bulk of Matabeleland and Mashonaland is granite, the remainder being mainly metamorphic schists. It is possible that this vast area of granite rock was at one time wholly or partially covered by sedimentary deposits, but, if so, these, with few exceptions, have been subsequently removed by erosion.

Sandstone deposits, with workable beds of coal, are said to occur near the Zambezi River. The metamorphic schists constitute the gold belt of the country. They occur as broad bands and patches in the granite. There is little doubt that these schists have been derived from igneous rocks, by mechanical metamorphism, produced by earth-movements. It is chiefly in this region of intense metamorphism that the quartz veins occur, the rock of the veins being in the majority of cases a highly foliated chloritic schist.

(J. H. Hammond, British South Africa Company's Report, 1892–94, p. 72.)

109. From the sea coast to Chocho the country rises by gradual ascent; the soil is a strong red clay and mould (p. 56).

From Chocho to Kusu is a range of grey granite hills running west-north-west to east-south-east, while the soil is a thin black mould. From Kusu to Katunga (Eyo) the hills are of soft crumbling granite (p. 56).

In the neighbourhood of Mussa River and Kiama is quartz and sandstone (p. 65).

From Kiama to Wawa the hills are of sandstone and clay-ironstone, the general soil being red clay and gravel (p. 78).

North-east of Wawa are hills of puddingstone, the pebbles of which are white quartz, angular and not water-worn.

Further north-east is dark grey slate, and the soil a strong blue clay (p. 97).

So also at Bussa is the same slate, forming the rapids (p. 104).

Near Songa, on the left bank of the Niger, is red and grey granite; just to the south are porphyry hills on both banks, and still further south on the west bank are ridges of clay-slate (p. 109).

North-east of Tabra the soil is a deep red clay, covered with a thin layer of sand (p. 145).

Further on, near Bullabulla, are clay and sand with large blocks of sandstone, in which are nodules of iron, and veins of clay-ironstone (p. 146).

In the neighbourhood of Womba the hills are of granite (p. 150).

And in the Gwari (Gbari) and Zaria districts and northwards, the soil is a deep red clay, with rocks of slaty sandstone (pp. 156, 157, 167).

Near Damoi and Namalik is granite (pp. 290, *sqq.*).

(Clapperton, "Journal of a Second Expedition into the Interior of Africa," London, 1829.)

110. Crystalline schists and primary rocks; the upper stratified being Triassic.

(Cornet, M.G., 1892, p. 126; and 1893, p. 41.)

111. For 12 to 20 miles south-west from Berbera is a belt of marine-formed sand, which gradually rises inland. Much of this sand is composed of disintegrated coral. Here and there are marble-limestone bosses upheaved by granite.

Further west the ground becomes more rocky; gneiss, granites, syenites, and quartzites are the exposed rocks; these are intersected by veins and dykes of biotite, quartz, &c. There are flat-topped hills to north of this, capped with basalt.

Near Jig-Jigga chalky limestone frequently appears.

West of the Abyssinian frontier is chiefly basalt with the older schists, and older volcanic rocks underlying it.

Hawash Plain, Fantalle Hills, and Kassam Valley are of later volcanic origin, with masses of lavas, trachite, rhyolite, andesite, &c., and tuffs.

At Addis Abbaba there is very little basalt, but a whitish-yellow tuff-like rock.

The Mecha, Sobu, and Kwunchi Mountains form the south-east boundary of the basalt, though basalt covers the country to the south, but only in small quantity.

Between Chellia (Chellahal) and Bilo is black sandy loam.

West of Soddo Range, which is of recent volcanic origin, are rounded basalt-covered, knoll-like downs.

The Sarti and Gumbi Mountains are both basalt on the surface and, underlying this thin layer, are schistose, slaty, granitoid and gneissic rocks several thousands of feet thick.

Similar down-like country succeeds, as far as the Dabus River.

The Beni Shangul are similar to the Sarti and Gumbi Ranges.

(Koettlitz, Dr. R., G.J., 1900, vol. xv, p. 264.)

South of Addis Abbaba the Lakes Zwai and Hora are connected by a river which flows between banks of chalk 100 feet high.

(Wellby, G.J., xvi, 1900, p. 296.)

112. The Nun district is made up of old crystalline rocks (granite).

(Douls, "Voyage d'exploration à travers le Sahara occidental," B.S.G., 1888, p. 456.)

113. The Tiris region is granitic.

(Quiroga, "Observaciones geologicas hechas en al Sahara occid.," Anales de la Soc. Espan. de Hist. Nat., 1889, pp. 337, *sqq.*)

114. The plateau of Tummo to the south of Fezzan consists of the dark sandstones of the Devonian period, being the prolongation to the south-east of the Tassili of the Azjer, which is of the same formation.

(Rolland, "Géologie du Sahara Algérien et aperçu géologique sur le Sahara," Paris, 1890, p. 238.)

115. Air is encircled on the north by a plateau of dark Devonian sandstone.

(E. von Bary, Tagebuch des verstorbenen, Z.G.E., 1880, pp. 345, *sqq.*)

116. The Tassili Plateau, north of Ahaggar, is also of dark Devonian sandstone.

(Roche, "Documents relatifs à la mission Flatters."—Ministère des Travaux publics, Paris, 1884, p. 341.)

117. In the Sus neighbourhood the anti-Atlas are formed of Palæozoic schists.

(Lenz, "Timbuktu," Leipzig, 1884, p. 290.)

118. South-east of Tenduf is limestone as far as 26° N.; then follow sand dunes to 25° N.; then, keeping the same direction, comes a granite district and quartzites to as far as 24° N., followed by schists (Schiefer). The Areg-el-Shesh is a sand plain, and just north of 22° the limestone reappears.

Round Tandeni are red sandstone hills.

Due south of this are sand hills and stony plains, and in the neighbourhood of 20° N. are quartz blocks.

Further south between 20° and Timbuktu is a sand plain and hills.

To west of Timbuktu, on the Niger bank, are sand dunes.

Near Bassikunu and then south is laterite.

West from Sokolo and on approaching Bachuinit is sand, followed to the west of the latter by laterite and clay-slate (Thonschiefer.)

South-west from Nioro lies wooded country followed by laterite and mountains of clay-slate (Thonschiefer), and sandstone.

(Lenz, "Timbuktu," Leipzig, 1884.)

119. The country between Ngaundere and Sukunga is of recent volcanic origin.

(Mizon, B.S.G., 1895, p. 354.)

120. An immense deposit of middle or earlier Cretaceous sand, without fossils, covers Nubia and the Libyan Desert from Kordofan to the confines of Kufra and Dekhel.

(Zittel, "Ueber den geologischen Bau der libyschen Wuste," Munich, 1880, map.)

121. The Dekhel and Kharga (Khargeh) are upper and middle chalk (*ibid.*).

To north and north-east of Kharga (Khargeh) is lower Eocene limestone, at the base of which is a narrow band of Esna shales followed by the Danian series (white chalk and ash grey clays, and the Exogyra Overwegi series); upper Danian also lies to north-west. The bed of oasis is formed of Nubian sandstones and clays, with a strip of blown sand running north to south, and interrupted towards the north.

(Ball, "Kharga Oasis," Cairo, 1900, map.)

To north of Dakhla is white chalk and chalky limestone; to south is Nubian sandstone, with a band of blown sand running south from Dakhla. The oases consist of patches of cultivable loam and sand; and between oases and north plateau is a narrow band of lower Danian clays, &c.

(Beadnell, "Dakhla Oasis," Cairo, 1900, and maps.)

122. The massif of Air, a complex system of ancient and eruptive rocks, rises to a height of 1,800 metres with its walls of basalt and columns of trachyte.

(Barth, "Reisen und Entdeckungen in Nord- und Central-Afrika," Gotha, 1857, I, pp. 421, 567, 587.)

123. The mountains of Anahef are of granite.

(*Ibid.*, I, p. 291.)

Foureau gives quartz and granite.

(B.S.G., 1900, vol. ii, p. 436.)

124. The Haruj-es-Sod is a mass of calcareous rocks and sandstones.

(Rohlfs's "Kufra," p. 180.)

125. The Utangule Mountain mass consists of basalt, rhyolite, and trachyte.

(Dantz, M.D.S., 1900, p. 41.)

126. On the Ivory coast there is a narrow coast belt—sometimes very narrow, sometimes extending 40 kiloms. inland—

consisting of quartzose marine sands mixed with shell débris and clayey alluvium brought down by the rivers.

The inland portion is composed chiefly of gneiss and mica-schist, overlying which is a thin layer of vegetable matter.

(Thomasset, of the Houdaille Mission, A.F., 1900, p. 166.)

127. Near Gail, in Niellim country, the Shari makes a great bend, and is cut by huge granite blocks.

(Prins, B.S.G., 1900, p. 179.)

Higher up, the banks of the river are of sand and sandstone, which crumbles at the least touch, and conglomerates (*ibid.*).

Togbao Mountain and other hills are crowned with granite.

(*Ibid.*, p. 182.)

The banks of the Shari, up to its confluence with the Gribingi, are formed of siliceous and argillaceous conglomerates.

(*Ibid.*, p. 184.)

Further north the banks are of sand (Mainfa neighbourhood).

(*Ibid.*, p. 187.)

The banks of the Logon are of similar conglomerates.

(*Ibid.*, p. 189.)

The Dar Runga neighbourhood is chiefly composed of granite rocks, with argillaceous sands in some places, and the mountains are covered with granite worn round.

(*Ibid.*, p. 194.)

Near Gribingi post, Kaga Bandero and some other hills are of a soft sandstone.

(*Ibid.*, p. 194.)

Iron is largely present in all the above.

(*Ibid.*, p. 194.)

128. The highlands of Asgar, north of 24° N., are of black sandstone; Mount Idinen consists of a huge mass of rock formed of marl and limestone strata resting on black sandstone with serrated crests and turreted pinnacles of sandstone.

(Barth (a), vol. i, p. 171, map.)

To the south-west of Asgar is an extensive waterless plain with granite (*ibid.*).

Almost half way between Ghat and Air, north and south of Mararraba, are gravelly plains with isolated granite peaks.

(Barth (a), vol. i, p. 241, map.)

South of Asiu (near In-Azawa) are red and green slate-sandstones succeeded farther south by a low granite range and gravelly plains (*ibid.*).

North of Mount Kadamellet are dark gneiss and fine-grained marble (*ibid.*). (See Note 188.)

129. In about 17° 20′, going south from Air, the granite begins to disappear and to be replaced by sandstone formations.

(Barth (a), vol. i, p. 297, map.)

South of 17° are sand hills and sandy plains, and then follow the pasture lands (*ibid.*).

130. In the neighbourhood of Say are sandstone and calcareous rocks.

(Barth (a), vol. iv, p. 104, map.)

131. Between Say and Bundore we have first hills of red sandstone with granite, then near Sirba River gneiss and mica-schist and marble.

West of Bundore are gneiss, granite and sandstone.

At Sebba is red clay, and west of it granite and gneiss, and at Tumpenga large granite boulders.

On the Bugoma are granite and gneiss, followed on west by gneiss and mica-slate.

South-east of Tondi are sandy downs and at Tondi are granite peaks (*ibid.*).

At the south foot of the Hombori Plateau is the Seno sandy tree-clad region, which is reached from the heights by crossing three parallel dunes. The winter rains from the heights disappear in the sands, cross the dune belt, and reappear 100 kiloms. further south, forming reservoirs which are the sources of the Voltas.

(Chanoine, B.S.G., 1899, p. 224.)

132. On left bank of Niger, between Gao and Tosaye, are sandy downs and sand hills, and at the latter sandstone cliffs.

(Barth (a), vol. iv, p. 250, map.)

133. Above the fine yellow clay-schist of Manyema, the banks of Tanganyika reveal 50 feet of shingle mixed with red earth; above this at some points great boulders lie; after this 60 feet of fine clay-schist, then five strata of gravel underneath, with a foot stratum of schist between them. The first seam of gravel is about 2 feet, the second 4 feet, and the lowest of all about 30 feet thick. The fine schist was formed in still water, but the shingle must have been produced in stormy troubled seas, if not carried thither by ice and at various epochs.

(Livingstone (1), vol. ii, p. 60.)

134. A great band, 150 miles wide, consisting of volcanic rocks, in which are embedded sandstones altered to schists, extends from the Vaal to a distance of 60 miles north of Victoria Falls.

To the north of Kuruman is *basalt, of which also the Amban Mountain, to west-north-west, is composed.

There are black *basaltic mountains on the east of the Bamangwato.

(*Ibid.*, pp. 215, 216, 217.)

135. Above the Kebrabassa Rapids, the Zambezi flows through a great bed of shingle and gravel of well-rounded stones, the pebbles being of hard crystalline rock.

The Loangwa Valley is the bed of the ancient lake with banks 60 feet thick of the same formation.

(*Ibid.*, pp. 219, *sqq.*)

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* It must be borne in mind, as pointed out by Hübner in his "Geognostische Skizze aus Sud-Ost-Afrika," M.P.G., 1872, xi, that the igneous rocks, which Livingstone calls trap and basalt, and which he found in the great central plain, are, in reality, greenstones, and consist mostly of a compact conglomerate of oligoclase and hornblende.

136. Near Shamoara, which is close to the Zambezi–Shire junction, are quartz hills.

(Livingstone (2), p. 33.)

The Kebrabassa Range is formed chiefly of syenite; blocks of granite also abound, and these with metamorphic rocks contorted and twisted into every conceivable position.

At Tete are sandstones, and also at Lupata.

(*Ibid.*, pp. 54, 184.)

137. A range of metamorphic rocks extends from Senna to Mount Makanga and bounds the Shire Valley on the west.

(*Ibid.*, p. 89.)

138. The mountains near Kalibe Island and the surrounding district are generally of igneous or metamorphic rocks, clay-slate or *trap; the principal rock of the central part of the country, where no syenite or gneiss has been upheaved, is a grey coarse sandstone, similar to that found at Tete.

(*Ibid.*, p. 222.)

139. On each side of the Ruvuma are plateaux of masses of grey sandstone capped with masses of ferruginous conglomerate.

About 60 miles up from the sea, the plateau is succeeded by more level country, with detached granitic masses. The sandstone of the plateau has first been hardened, then quite metamorphosed into a chocolate-coloured schist.

Going farther west, there are long tracts of gneiss, often striated. From these striated rocks have shot up great rounded masses of granite or syenite. The elevated plains among the mountain masses show great patches of ferruginous conglomerate.

About 40 miles from the Lake Nyasa is a good deal of quartz.

Near the lake and on the eastern shore are mica-schist and gneiss foliated, with a great deal of hornblende, the rocks being all tilted on edge or slightly inclined to the lake.

On the east side of the lower part of the lake are two ranges of mountains, evidently granitic.

(Livingstone's "Last Journals," vol. i, p. 83.)

Makonde district north of the Ruvuma is of sandstone. The whole of this Ruvuma Plain is made up of granite and gneiss and metamorphic rocks. But between Itule and Kwamakanja, for a length of nearly 20 miles, and nowhere more than a third of that in breadth, is a hollow or pocket of bituminous shale.

(Thomson, P.R.G.S., 1882, p. 70.)

140. The Bakaa Mountains are formed of *basalt.

(Livingstone's "Missionary Travels and Researches in South Africa," 1857, p. 10.)

The soil of the Kalahari Desert is a light soft sand, nearly pure silica, but the beds of the ancient rivers contain much alluvial soil.

(*Ibid.*, p. 47.)

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* See Note on p. 56.

141. The rocks on the Zambezi above Sesheke are reddish hardened variegated sandstone, which, with the broad horizontal strata of *trap, sometimes 100 miles in extent, and each having an inch or so of silicious matter on it, form a great part of the bottom of the central valley.

(*Ibid.*, p. 214.)

At the confluence of the Njoko (Nyoko), the soil is of rich alluvium and sand. The Njoko Valley is skirted on either bank by forest on white sandy undulations, unbroken for many hundred miles, save by similar valleys.

(Gibbons, G.J., 1897, vol. ix, p. 124.)

142. Below the Kabompo junction is marly sandstone.

(Livingstone's "Missionary Travels and Researches in South Africa," 1857, p. 260.)

The elevations in the Liba or Leamba–Zambezi meadows are of soft sandy soil, and the meadows themselves of black rich alluvial loam.

(*Ibid.*, p. 265.)

143. Near Lake Kisale are horizontal beds of sandstone.

(Delcommune, M.G., 1900, p. 146.)

144. The neighbourhood of Lake Dilolo is formed, on the surface, of ferruginous conglomerates; underlying these is red shale with banks of gravel.

(Livingstone (3), p. 569, section.)

145. The lower Nile has cut its way down through the †Eocene sandstone, in which bands of clay are not uncommon.

At Assuan are granite and schists; these are covered, at some distance from the cataract, by white freestone over which lies grey and purple sandy shale, followed by coarse brown grit.

(Hull, Qr. J. of Geology, lii, 1896, p. 308.)

146. The plateau contained between Lakes Victoria, Albert and Albert-Edward is composed of quartzite clay, clay-shales and slates, the quartzite being uppermost.

(Hermann, M.D.S., Bd. xii, Heft. 3, 1899, p. 168.)

147. Along the course of the Congo, from the Pool to the mouth, we have from the Pool to Katuba red sand; thence to Issangila shales, thence to Boma crystalline schists, thence to mouth a narrow strip of alluvium, followed both north and south by laterite, which extends up and down the coast in a narrow belt as far north as Nyanga and south as far as Ambriz.

(Tappenbeck, M.G., 1886, p. 87.)

148. Between the Jur and Wau, between Dem Zebehr and N'Doruma, in fact in the whole of this region, the soil is of red laterite overlying granite and gneiss, which in places crop out. South of the Bomokandi River it is the same. The Ghasa Plateau is gneiss, and in the valley of the Bomokandi, north of Liwanga, the laterite gives place to grey sandy clay.

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* See Note on p. 56. † Rolland makes this Cretaceous, see p. 21.

In A-Madi land the laterite is yellow instead of red, and there are also beds of hard red sandstone.

(Keane's Translation of Junker's Travels in Africa, vol. ii, pp. 79, 116, 120, 321; vol. iii, pp. 16, 34 72.)

149. The Tertiary series (Oligocene and Pleistocene) is largely developed in the neighbourhood of Shott Merwan, and in the valley of Wad Rhir, between Biskra and a point a little south of Tuggurt.

The region of Hamada, extending from Wad Kheshabe to Inifel, and reaching from Grand Erg on the east to El Golea on the west, is formed of puddingstones and calcareous travertine of Pliocene age.

(Flamand, A.G., 1900, p. 233.)

150. Uhehe and Usagara regions: here gneiss is the prevailing rock. In Khutu are also found districts of the older Karoo formation (sandstone and shale).

(Dantz, M.D.S., 1900, p. 126.)

All round the Uchungwe Mountains (in Uhehe) is good alluvial soil.

(von Bruchausen, D.K., 1/10/97.)

151. The Congo-Zambezi parting between the Lufila and the Loenge (Lenge), and between the latter and the Kafubu (affluent of the Luapula), consists of grey schists.

(Voss, of Lemaire's Mission, B.C., 1900, p. 317.)

Between 12° 11′ S., 25° 38′ E., and 11° 50′ S., 25° 53′ 58″ the neighbourhood of the parting is calcareous.

(Questiaux, B.C., 1900, p. 437.)

152. Both branches of the Luao, which joins the Kassai north of Lake Dilolo, flow in granite beds, and south of this is quartz porphery under sand.

(Lemaire, B.C., 1900, pp. 318, 330.)

To south of Naivasha Lake are volcanic peaks and ridges, whose slopes are covered with volcanic dust, obsidian and lava rock.

(Grogan, G.J., vol. xvi, 1900, p. 78.)

153. Between Ankober and Balji on the east, and the mountain chains of Toke, Dendi and Botor on the west, are calcareous beds. In the region of these chains, and that of the Roge and Leka Mountains, as far as the valley of the Didessa River, are tracts of red ochre clay.

The Western Abyssinian Plateau, from the valley of the Didessa to the Nile Plain, is covered with a deep fertile humus.

The bed of the Birbir is less basaltic than the surrounding regions and quartz is frequently met with.

The Baro flows between clayey banks.

(Michel, La Géographie (B.S.G.), 1900, vol. ii, p. 25.)

154. Tagama is a great undulating plateau, covered with thickets, the soil being sand everywhere, except at the bottoms of the dry pools, where clay is found.

(Foureau, La Géographie (B.S.G.), vol. ii, 1900, p. 49.)

155. The geological formation of Swaziland varies longitudinally; micaceous schists (Swazi-schists) lie on north-west border, but are cut off by a granite belt, some 50 miles in width, only ending on the extreme fringe of the middle terrace of the country. There the formation changes to sandstone, which on the east rim is cut by frequent intrusive dykes of gneiss. Then rise the Lebompo Mountains, a regular alignment of the metamorphic rocks, which divides the Swazi sandstones from those of Tongaland.

(A. M. Miller, P.R. Colonial Institute, xxxi, 1899–1900, p. 280.)

156. The region of the Congo–Zambezi water parting, in the neighbourhood of 11° 30′ S., is composed of schistose sandstones and quartzites;

(Lemaire-Questiaux, B.C., 1900, p. 365.)

And near Sakabinda (12° 14′ 26′ lat., 25° 16′ 20″ long.) of clayey shales in great vertical masses, with a general east-west direction, with viens of quartz.

(*Ibid.*, p. 388.)

157. The Saïda region is composed of Jurassic limestone.

(B.S.G. et Archeol., Oran, xix, 1899, pp. 429–484.)

158. The southern portion of the country to the east of Lake Rudolf is a succession of igneous rocks reaching down to the water's edge.

From the south end of Lake Rudolf north-west to 4° N. the high peaks are topped with white and pink sandstone dropping perpendicularly, the hillsides green with bush, with rocks of basalt here and there.

The bed of the Turkwell is sandy. The valleys generally fertile with rich alluvial and black cotton soil.

From the Ruzi source northwards the country is much the same, but sometimes displays a gravel soil.

(Wellby, G.J., xvi, 1900, pp. 298, *sqq.*)

159. The soil of Portuguese Guinea, which is almost entirely a plain, is argillaceous (laterite).

(Vasconcellos, "As Colonias Portuguezas," p. 38.)

160. The Fez Plateau is of chalk-marl and conglomerate.

(Lenz's "Timbuktu," vol. i, p. 126.)

161. From In-Azawa southward to Air, Foureau's route lay along granite chains.

(B.S.G., 1900, p. 245.)

162. The mountains of the Upper Wad Nefis and the Gundafi district to the south of Marocco city are schistose.

(Segonzac, B.S.G., 1900, p. 292.)

163. The whole M'Bomu basin and also the outer rim of the Congo basin is composed of rocks, older than the carboniferous on a bed of gneiss and mica-schist.

(Bonnel de Mézières, B.S.G., 1900, vol. ii, p. 307.)

164. East of Klugu River and north of Karaga (10° N.) the soil is argillaceous, covered with ferruginous agglomerations, and is quite impermeable.

South of Karaga are ferruginous and friable sands.

(Binger, "Du Niger au Golfe de Guinée," 1887–89. Paris, 1892, pp. 62, 69.)

165. The whole region of the Bahr-el-Ghazal, extending from about 27° 20′ E. to 30° 50′ E. and from 4° 30′ N. to 9° N. is a vast ferruginous plateau, with here and there a granite peak of some 300 feet in height, with a gentle slope from south to north.

(Roulet, B.S.G., 1900, ii, p. 306.)

166. At Pointe-Noir, near Loango, and in the neighbourhood of Libreville, are found fossiliferous miocene calcareous deposits, similar to those on the coast near the Congo mouth.

(Le Chatelier, B.S.G., 1900, II, p. 161.)

167. The upper valleys of the Niger and Senegal traverse great beds of sandstone, folded at the base, but horizontal at the summit, similar to the Permo-Triassic beds of the Karoo. Here also are found siliceous and crystalline limestone. All these beds lie on the primary schists, sometimes micaceous, frequently accompanid by granite, quartz, &c.

Below the region of the rapids the valley of the Senegal lies between the sand formations of Maures, Futa and Ferlo.

The regions of Kayor and Bayol, in Senegal, consist of various rocks, folded and faulted by the violent movements which accompanied the raising of the volcanic mass of Cape Verde, the whole covered by a great thickness of sand and laterite.

The following is the result arrived at from evidence procured on digging wells at (1) Thies and (2) Mbambe, both in Baol:—

1.	12	metres	sands and ferruginous gravels.
	4	„	flaky marls.
	6	„	gravels (conglomerated).
	2	„	sandy limestone.
	3	„	limestones (with bivalves).
	8	„	fissured sandstone.
	5	„	clayey sandstone.
	5	„	chalky limestone.
2.	3·5	„	sands.
	2	„	ferruginous gravels.
	3	„	calcareous gravel.
	10	„	marly limestone.
	3	„	compact limestone.
	2	„	flaky clay.
	2	„	limestone.
	–	„	(with ostrea).

Between Capes Rouge and Naze an examination of the cliffs showed a series of limestone strata, sometimes dolomitic, plunging at an angles of 10° towards south-west, with a thickness of 45 metres. South-east of Popengine these are replaced by strata of 25 to 30 metres of soft argillaceous sands, reposing on grey marls and blue clays—probably all Tertiary.

All the formations which have been mentioned are covered with laterite of variable thickness.

(Rambaud, "Une mission au Senegal," Paris, 1900, p. 325.)

168. The Omurambo and other tributaries of the Okovango River have cut deep troughs in the plateau which consists of clays and sands.

(v. François: M.D.S., iv, 1891, p. 207.)

169 From the Omurambo junction for 100 kiloms. the valley of the Okovango River is enclosed by wooded sandhills.

(Eggers, M.D.S., 1900, p. 187.)

170. A section on 27° 30′ N.: On the coast of the Red Sea are Pliocene followed by Miocene deposits. The crystalline rocks of the coast hills then protrude, followed by a small Miocene area. Then, always going westwards, occur sandstone, chalk and Miocene deposits in quick succession, the latter subsequently covered by Pliocene. Then follows an area of plains covered with water-worn detritus. Here the crystalline range, which runs parallel with the coast, forces its way through the sandstone, which appears on both flanks. This is again followed by a plain of detritic material, once interrupted by the upheaved strata of chalk, and Eocene deposits which lie over the sandstone. To this succeeds the crystalline rock of Jebel Om Mangul.

(Schweinfurth, "Aufnahmen in der Ostlichen Wüste von Ägypten," Berlin, 1900.)

171. At the entrance to Lake Debo (Niger) are lofty red sandstone rocks.

(Lenfant, R.G., November, 1900, p. 364.)

There is an outcrop of quartz and schists at Tundiforma.

(*Ibid.*, p. 365.)

172. The western portion of Wad Shaid lies between bluffs of sandstone. The sands of Wad Sibrit rest on a bed of impervious crystalline rock. In Wad Shaid, these rocks crop up near Jebel Sufra. Below the sands of Abu Had is granite rock. Thence to Sikait are crystalline rocks and schists. Geological section of Jebel Sikait.

(MacAlister, G.J., xvi, 1900, p. 537.)

173. Between 23° and 27° N. the mountains occurring in the region between the Nile and the Red Sea are formed of crystalline rocks, principally granite, but passing in places into gneiss and mica-schist, traversed by dykes and intrusions of greenstone, felsite and porphyry. It is in these rocks that most of the auriferous quartz veins occur. This central core is flanked on either side by conglomerate, Nubian sandstone, crystalline limestone, and Tertiary limestone in the order indicated.

(Alford, G.J., xvi, 1900, p. 557.)

174. From Inhimbane to the Limpopo the coast belt is of sand overlying limestone; the valley of the Inyanombi has a red sandy soil. Eshigibi stream has arenaceous limestone in its bed, and to the south-west of this is an outcrop of the same stone.

The immediate Limpopo Plain is rich alluvium, the area being enclosed by limestone plains.

A sandy ridge encloses the fertile plain of Inhimbane.

A limestone country extends northwards with large outcrops of the marble-like rock, here and there, up to the Sabi River, whose valley is bordered on each side by limestone bluffs.

The Murgis flows directly into the Bosi over a bed of trap, with eruptive dykes of a serpentine character.

This black trap dyke is the only one visible in the district. Just to the north of this begins a lofty (1,500 to 1,800 feet) stony ridge of porphyry and serpentine.

The Bosi River in this locality is bordered by deep precipices of sandstone and volcanic rock, the formation along Erskine's route being red clay-slate with eruptive porphyritic rocks.

South of Unswelizi River is porphyritic clinkstone, followed (going south) by red sandstone until the Sabi is reached.

In the angle formed by the Olifant's and Limpopo are limestone hills, while here on the south bank of the former are ridges of pebbles and cretaceous limestone.

Opposite the junction of the Terue River with the Olifant's are porphyritic hills. To the west of the Tali are volcanic rocks, whilst higher up on the right bank of Olifant's are mica and gneiss. (See Note 243.)

(Erskine, J.R.G.S., 1875, p. 45.)

175. From Tati to the Sabi River the character of the formation is essentially metamorphic, the range of low hills lying between the rivers is trappæan in character, and the isolated kopjes are composed of granite rocks (p. 4).

Twenty miles above the junction of the Tuli with the Shasha and on its right bank are granite, slate and quartz (map).

At Tolo Azime cataracts the granite rises perpendicularly from the gorge and is overtopped by basalt. Granite and hornblendic rocks lie scattered broadcast all over the right bank as far as a low line of hills in the distance (p. 15).

Between the Zoutpansberg and the Limpopo great hornblendic rocks encumber the whole valley (p. 18).

The Bubye River runs through a chain of basaltic hills (p. 20).

Below the junction of this river there are sandstone hills on the right bank of the Limpopo (p. 22).

Between the junction of the Nuanetzi and Lipaluli or Olifant's River, a distance of about 100 miles, the rising ground in the neighbourhood of the Limpopo is of coarse conglomerate intermixed with greyish sandstone (p. 27).

(F. Elton, J.R.G.S., 1872.)

176. The Campbell and Kuruman Ranges to the north of the Orange River are limestone. Slate and shale form the beds of the Rivers Snake and Mooi, west of Base Kop in Namaqualand, while on the Knaas River is a conglomerate of limestone, greenstone and garnets. In this region are many miles of limestone flats, some extending 10 miles in

length, bounded by sand dunes and isolated kopjes, with their pointed summits covered with bush. The most peculiar feature in this region are the sand dunes, which extend for many miles in every direction. They run due west and east and range from 50 to 200 feet in height.

Their base is a dark limestone covered with sand which varies in thickness from 4 to 10 feet. There are also many isolated granite hills.

The Brinus Mountains are granite, and so too is the district between the Higap and great Fish Rivers lying south of the Back River.

The region of the Great Fish River is of granite, gneiss, trap and amygdaloid. The coast country south of 20° S. to the Orange River is a sandy desert, the sand forming steep ridges extending 70 miles inland until they join the mountain slopes.

South of the Chinamba Hills, as far as the Zuga, the country is deep sand.

(Anderson, P.R.G.S., 1884, p. 18.)

177. The gold seam which runs through the provinces of Dadiase and Inkanta is a continuation of that which starts near Kibbi, Eastern Akim, and proceeds in a westerly direction through Western Akim, entering Ashanti near Amantia. This seam then passes through Dadiase and proceeding through a portion of Adansi country, near Fomena, strikes south and thence through Ikanta and so on into the Tarkwa country.

Kintampo is built in the midst of a large sandy plain.

(Kirby, P.R.G.S., 1884, p. 447.)

178. The peaks and ridges of the Namuli Mountains are granitic and metamorphic.

(O'Neill, P.R.G.S., 1884, p. 642.)

179. The northern slope of the Witwatersrand Plateau is formed of rocks belonging to the Silurian period and metamorphic series. The Magalies Berg is of white quartzite, which changes from compact to granular. The strike of the principal strata is from east to west, with a considerable dip to north.

In the hill ranges east of Rustenberg Flat is a porphyritic formation and diorite intersected with felspar and leek-green hornblende.

In the Highveld are sandstone layers.

On the eastern heads of the Limpopo are the primitive rocks, granite and gneiss, joined from north by steep raised, reddish, shining mica-schists, capped with clay-slate, but principally quartzite and greywacke; and then lower Silurian rocks may be followed as far west as the Mariko district, but there the clay-slates are much thicker. Above the greywacke is a layer of bluish siliceous limestone of vast extent and considerable thickness, and horizontal throughout.

Devonian limestone extends from the sources of the Mooi

River as far as the higher Mariko district and beyond the Harts River.

(Mauch, M.P.G., Ergan, No. 37, 1874.)

The geological structure of the country between Potchefstroom and Tati is summed up thus: round a granite core, the periphery of which does not appear to be a simple ellipse, but a many-limbed curve, lies a mantle of metamorphic rocks, which have been frequently fractured and intersected by greenstone; older sedimentary formations appear in one place in the south and again under lat. 20° S.

The long rugged mountain ridges near Potchefstroom and Rustenberg are quartzite. On the Limpopo the sandstone lies immediately on the granite. Ferruginous mica-slate shows itself at Tati, overlying chlorite slate.

A considerable portion of the country between Potchefstroom and the Inyati, notably the Shoshong Mountains, is of greenstone. The Pilandsberg is also of this formation. Sedimentary rocks appear in lat. 23° 30′ S. and 26° 40′ E. long.; these are upheaved sandstones, lying between the Serorume and the Limpopo, of Karoo age.

(Hübner, M.P.G., 1872, No. xi.)

180. Eastward of Pretoria, after passing Potgieter's Rust (Makapans Poort), a region of an immense system of metamorphic slate is entered. The dip and strike change a good deal, as must be expected in contorted and flexured strata, but on the whole a strike from east to west can be observed. The strata are very steep, the dip, principally to the north, varying between 35° and 39° The separate layers are mostly very thin. The slates are discordantly overlapped by a very hard and compact sandstone, frequently taken for quartzite.

In the south-east of this, the Marabas Stadt district, follows hard siliceous limestone.

Region between Lydenburg and Delagoa Bay :—

This may be divided into three plateaux—

1. The high mountain country between Lydenburg and the steep ridge east of Spitzkop, about 26 miles broad. It contains an immense formation of shales with stratified sandstone ledges, capped here and there by dolomite.
2. The mountain country between the first plateau and the eastern slopes of the Lebompo Mountains. Almost all the rocks found here are crystalline, chiefly granite; and, on the eastern slope, melaphyre and quartz-porphyry.
3. The coast lands between the Lebompo Mountains and the ocean: In the west are low hills of porphyry and melaphyre; the rest is flat and covered with black marshy soil, in some parts covered with recent sea-sand.

(Cohen, Neues Jahrbuch für Mineralogie, Geologie und Palæontologie, 1873.)

At Morokweng granite is visible, in the bed and round the borders of its fine vlei; but it soon disappears, overlaid by a shallow silico-calcareous formation. The pans are almost always of limestone, and where pits exist in this part, they are dug out of limestone.

North of this is loose sand.

(Wilkinson, G.J., 1893, vol. I, p. 326.)

In the Kalahari the formations in ascending order are :—

1. Granite, the bed-rock of the whole country, which comes to the surface about the head of the Molopo or Molapo (Molopo) River at Mosita, at Morokweng, and along the Mashowing River near Madebing.
2. A series of hard crystalline silico-calcareous beds, occurring in great force near Kuruman, but thinning away northwards.
3. A series of highly altered shales, very ferruginous and highly magnetic. Their outcrop forms a distinct escarpment which can be readily followed for hundreds of miles, hard and in thin beds and much broken up. This outcrop forms the range of hills near Madebing, through Honing Valley to near Sekeleke, and may be considered as the proper physical boundary of the desert, for the deep sand begins immediately behind them.
4. A series whose outcrop is everywhere hidden by the sand, probably sandstones, shale and quartzites.
5. A large series of hard impervious quartzites, forming the Maubelle, Tsebun, Mararalen Ranges, and also the westerly dip of the Great Molapo bend, near Mokopon.

(Penning, G.J., 1893, vol. i, p. 336.)

181. The Murchison Hills, lying between two districts of granite and gneiss to north and south, are formed of the eroded remains of clay shales, schists and mudstones, resting on granite and plentifully intercalated with quartz.

(Alford, G.J., 1893, vol. ii, p. 226.)

182. At Edea (Idia) Falls are gneiss rocks.

(Grenfell, P.R.G.S., 1882, p. 586.)

Below Edea, on the western bank of the stream connecting Lake Lungasi with the Sanaga River, is laterite.

(von Stein, M.D.S., 1897, p. 155.)

183. (*a*) In the north of Tunis, between the sea and Wad Mejerda, in Bizerta neighbourhood, the formation is calcareous, Jebel Ahmar in the north-east part is composed of red sandstone of the upper Eocene and Oligocene periods. A small miocene synclinal separates the range from the mountain masses of Mogodo and Aïn Draham, which are entirely of Numidian sandstone. To the south-west of these mountains are small calcareous chains.

(*b*) In the zone between Sbeitla and the Shotts; Jebels Sehib and Rosfa and Jebel Berda are of Cretaceous rocks flanked by lower Eocene; Jebel el Ayasha is calcareous, with marls, the whole of the southern half

sinking under the plain. Jebels Serragia, Jellabia and Geltar, and the chain to the north-west of Gafsa, are the continuation of the Algerian Mountains, and, with the exception of a Quaternary interruption at Wad Sidi Aïsh (or Baiesh), are entirely Cretaceous.

(*c*) In the zone between the above: In north-east are hard dark calcareous rocks (Lias), in the centre these rocks are often dolomitic.

(Pervinquière, A.G., 1900, p. 434.)

184. The coast belt north of St. Louis, as far as Marsa (at least), is a great plain sloping gently to the sea, probably Pliocene, sometimes with shell marl, sometimes with gypseous crystal (described as mica by previous travellers). The country is not of the Sahara type, but is a northern prolongation of Senegal country; numerous dunes appear, not higher than 10 meters, with a general north-north-east direction. These are clothed with vegetation. Along the coast itself, too, is a line of dunes (reaching a height of 200 meters). This kind of country extends for 200 kiloms. from the coast. Eastwards of this (*i.e.*, of Twizekt) the soil is composed of sand and ferruginous quartzites, with traces of quartz and manganese. Numerous faultings run north and south, the beds having a westerly inclination and a dip varying from 80° to 35°, the entire surface having been levelled by erosion. This formation extends over a belt of 100 kiloms. as far as Tabringut (which ought to be 80 kiloms. east-south-east of its position on French staff map).

Then occurs a crystallophylline plateau, extending from the Sebkha of Ijil on the north to Bakel on the Senegal River, which is terminated by an abrupt cliff, 175 metres high, and extending for the same distance. Here the quartzites and sandstone are perfectly horizontal.

The plateau of Adrar forms portions of this abrupt rise, and has north to south faultings similar to those in the country farther west, but inclining more to the east as one proceeds northwards. In Adrar are ferruginous sandstones.

(Dereims, of the Blanchet Mission, A.G., 1900, p. 458.)

185. The soil in the valley of the Likuala-aux-herbes is siliceous sand and granite alternating with limonite.

(Jobit, B.S.G., 1900, vol. ii, p. 349.)

186. South-west from the Webi Shebeli, near Hilowen, is a granite plateau with iron ore, reaching to Gohule.

Between El Dere and Le are many limestone mountains.

(D. Smith, G.J., xvi, 1900, pp. 601, 602.)

187. In the Northern Territories of the Gold Coast, *i.e.*, roughly from 8° to 11° N., the basis of the soil is sandstone, covered in the low levels by a thin layer of alluvium.

In the hills granite and quartz are found.

(Northcott, G.J., xvi, 1900, p. 683.)

188_1. Between Tadent and Tajenut are schists and granite.

South of Tadent to In-Azawa is a sea of rocks; consisting of a quartz-gravel plain with blocks of granite.

The Iferuane region is of quartz, granite and gneiss.
Azawakh is an arid desert region with small mountains of red sandstone.
At Zinder are great blocks of granite.
On the east of Lake Chad are low sand hills. (See No. 128.)
(Foureau, B.S.G., 1900, p. 436.)

188. An escarpment of limestone (upper Cretaceous) extends through the oases of Farafra, Dakhla, and Kharga, being broadest at the first-named, and narrowing from the last, and making a southern semi-circular curve through Dungul, and north to Kurkur oasis, and continued northwards to Esna. On the east side of the Nile this narrow band is continued eastwards; the escarpment also extends westwards from Farafra. The oasis of Baharia is also limestone.
South of this limestone the Nubian sandstone comes to the surface on both sides of the river, extending at least as far south as Selima oasis.
North of the limestone escarpment lie Eocene beds (limestone with clays and sandstones) on both sides of the river, and extending to a little north of 30° N.
South of Wadi Natron, and west of Fayum, is a circular area of sandstone (J. Ahmar sandstone).
Bounded on the east by a Cairo–Alexandria line, and north of the Eocene areas, are Miocene beds (limestone and calcareous sandstone, with marls and clays of marine origin). These extend south-west to Siwa and further south.
On the east side of the Delta region (Alexandria–Cairo–Port Said) the formation is the same as the above.
The Delta region is made up of alluvial deposits.
South from Wadi Araba is a coast belt of alluvial deposits, followed by a belt of crystalline rocks (Archæan), to which succeeds a third belt of limestone, the last-named only extending as far as 26° N.
(Lyons, Qr. J. of Geology, with map, November, 1894, vol. i; see also De Lapparent, p. 1202.)

189. Round the south shores of Tanganyika are horizontal beds of Old Red sandstone, and between Tanganyika and Rukwa is a series of high ridges of granitoid rocks. On the west, too, are enormous deposits of reddish sandstone, conglomerates and quartzites. Near the south end these stratified masses are exposed to a depth of 2,000 feet. These deposits extend to an unknown distance west, and appear to fringe a part at least of the circular cavity of the Congo basin. They are also continuous with the beds which extend into the northern portion of the Nyasa district, and at Mount Waller form a narrow sedimentary neck among the surrounding granitoid hills, and pass thence to an undetermined distance east. These deposits have no fossils, and are the oldest deposits in this part of the interior. In places they are unconformably overlaid by newer beds of lacustrine origin, notably between Nyasa and Tanganyika,

and also about Maswa on Tanganyika, and again between Ujiji and the north end of that lake.

The bar of the Lukuga outlet consists of a number of ridges of exposed conglomerates, evidently formed at the bottom of the lake. The river finds its way over these, and crosses a flat sandy plain to the low sand hills, which here bound Tanganyika on the west, and once formed a portion of the old lake bed, continuous with the sandy plain.

The north end of Tanganyika basin, beyond the lake, is a flat mass of lacustrine and alluvial deposits, extending 30 miles beyond the lake.

The ridges cutting the Rusisi Valley are eruptive, and the shores of Lake Kivu are a continuation of the Tanganyika trough, the plateaux on either side being eruptive granitoid, extending east and west of the valley as far as Albert Nyanza.

To the north of Kivu is the great Kirunga (Virunga) volcanic area.

On the north, Albert-Edward Lake is bounded by a succession of low cliffs and profound swamps, the cliffs being composed in some places of old lake deposit, and in others of volcanic ash overlying this deposit. The Semliki Valley is composed entirely of these modern deposits, covered with forest and marshy growths.

(J. E. S. Moore, G.J., xvii, p. 1, 1901.)

190. North of Hoste's Camp, near the Loangwa River, are granite kopjes. West of Chewala, on the Matizi branch of the Kafue, are granite hills.

(Chesnaye, G.J., xvii, 1901, p. 42.)

191. The massif of Naba, which reaches an altitude of 2,170 metres near N'zo, is composed of granite and sandstone.

(Woelffel, B.S.G., iii, 1901, p. 37.)

The soil of the whole region traversed by the Woelfel-Mangin Mission, *i.e.*, between 9° and 6° 41′ N., and 6° 40′ and 9° 40′ W., consists of sandstone, granite and ferruginous blocks. The subsoil is a mixture of gravels (nodules of sulphate of iron) and ferruginous clays. In the forest country there is an upper layer of vegetable humus, overlying clay (*ibid.*).

192. The upper part of Hakim (south of Harar) is Jurassic limestone, and thence to Ennia-Gallaland is hard grey Jurassic limestone with yellow sandstone. There are also Jurassic rocks down to the Web River and south of Sheikh Hussein. North-east of Abunas are Cretaceous beds. On the Upper Hawash are young eruptive rocks, and the Didda Plateau is of the same.

(Neumann, V.G.E., 1900, p. 479.)

193. *1st Zone.*—From Wesso to the confluence of the N'Jadie and the Ivindo, consists of sandstone, and white and greyish sand. All the right affluents of the Sanga River above Wesso, the rivers and streams forming the Mossaka, and the numerous tributaries (left) of the N'Jadie, flow through

this formation, sometimes covered by puddingstone (ferruginous) of recent origin.

2nd Zone.—From above the confluence to the M'Vung River, *i.e.*, all the right slope of the Ivindo basin, is made up of a gneissic series. The mean type is granulitic gneiss, passing to leptynite.

3rd Zone.—Between the Rivers M'Vung and Okano, *i.e.*, a region with Zwameiong as centre; in this region the gneiss passes into granite.

4th Zone.—From Okano River to Mekonga Mountain. Here occurs a series of phyllites and quartzites, in the midst of which are granites.

5th Zone.—From Mekonga Mountain to waterparting between the Ogowe and Bokue. Here the granite predominates, and contains hornblende here and there. This zone forms the northern extremity of the Monts de Cristal.

6th Zone.—Maritime. Hence the eruptive rocks disappear, and are replaced by well-stratified sandstone, followed near the coast by shales alternating with the sandstone. Finally, in the neighbourhood of the sea are marls and shales.

(Dr. Spire, of the Fourneau-Fondère Mission, M.G., 1901, p. 66.)

194. On the north bank of the Ubangi River, and in the basin of the Kota River, *i.e.*, between Wango on M'Bomu and Mobaye, the substratum is covered by clay and sand, and limonite is everywhere abundant, the most frequent rocks being granite, schists and sandstone.

(Julien, B.S.G., iii, 1901, p. 112.)

195. Zaberma, or Saberma, is a sandy tract, but where not cultivated, is covered with brush.

(A.T.— —, A.F. Suppt., No. 2, 1901, p. 25.)

196. Below Kafukwe junction the banks of the Zambezi River are of clay mixed with gravel (p. 112).

Katiba Gorge, and just before Guai junction, at the series of rapids, is basalt (pp. 113, 114).

On the high ground east of Sesheke, at an elevation of 2,000 feet above the Guai River confluence, are gentle sandy undulations (p. 116).

The inundated plain of the Okovango River is bounded by dark yellow sandy undulations (p. 120).

North of Gulwana the banks of the Zambezi consist of slabs, 5 metres thick, of calcareous deposit and sandstone in several layers, with white sand intervening (p. 124).

In the neighbourhood of 13° 7′ S. there is much limestone.

The Congo–Zambezi watershed from Mumbeshe source is red clay (p. 128).

(Gibbons, G.J., xvii, 1901.)

From Kwando–Kubangi junction to the Lungwebungu River, and down this to its junction with the Zambezi, are undulations of sand covered with forest, interseeted by rivers flowing through alluvial valleys. The same is the case on the Upper Lucna River.

(Quicke, G.J., xvii, 1901, p. 130.)

197. The whole coast belt of Casamance is sand; in the beds of the marigots is a tenacious clay, while the interior is composed of clay and sand, probably laterite converted into humus by the vegetation, but not having the red colour of the usual West African laterite.

(Chevalier and Cligny, A.G., 1901, p. 166.)

198. For a study of the country round Palapye (map) and thence to Mafeking, see Zeitschrift der Gesellschaft für Erdkunde, 1901, No. 1, p. 20, by Passarge.

199. The belt on either side of the Suez Canal consists entirely of recent deposits. To the north-west of the Gulf of Suez, Jebel Genef, Jebel Anebet and Jebel Ataka are Eocene, and between these lie Miocene areas.

(Charles-Roux, "L'Isthme et le Canal de Suez." Paris, 1901, p. 3, vol. i, map.)

200. All the mountains which bound the south edge of the plateau north of Zambezi R. are composed of schists and quartzites. The plateau itself (Matoka) is generally found to be sandstone, usually horizontal. Some large areas are covered with crystalline limestone, notably east of Mwembezi River and near sources of Shoa River. Granite outcrop is scarce. Chafuguma, Suka and other hills to north are composed of ferruginous sandstone; ferruginous conglomerate covers large portions of the country.

(Grey, G.J., xviii, 1901, p. 69.) (See Note 105.)

201. The district of the Farafra and Idalia oases consists of white chalk, enclosed wholly on the east, and partially on the north, by plateau limestone, and enclosing an area of blown sand. Between the oases is another area of plateau limestone. The flanks of these plateaux, where surveyed, are composed of Esna shales. On the route from Farafra to Baharia, near 27° 45′ N., begins an area of clays and sandstones. To the south of Idalia is blown sand.

(Beadnell, "Farafra Oasis, its Topography and Geology." Geological Survey Report, 1899. Cairo, 1901, map.)

202. Jebel Kordofan consists of granite, flanked by mica-schist and gneiss, so, too, does Jebel Habila. West of Delen is a small granite range. Wodda consists of low granite hills. Golfan is composed of granite and crystalline schists, and the same formations are found in the Tagoi Hills, which rise 200 to 300 metres above the surrounding country, though Jebel Tagoi itself is of gneiss. From Kadero south to Kawalib is sand with low granite hills.

(Dr. Linck, V.G.E., 1901, p. 217.)

203. The country between Hensa and Lasman (about 50 miles south-west of Zeila) is volcanic; so, too, are the Kobul Hills, while Zakwala Mountain (10,000 feet) to north of Lake Zwai is an extinct volcano.

(Harrison, G.J., xviii, 1901, p. 258.)

204. The soil of the Sheliff Plain is chiefly either argilo-calcareous or argilo-siliceous.

(Pourcher, "La Plaine Chelif," Alger, 1900.)

205. In the district between Mossamedes, Huilla and Kihita, and the Gambos country, eruptive rocks (Gabbro) are abundant. In the Gambos country are large stretches of siliceous formation like the deposits of geysers.

(Choffat-Da Silva, Portugal em Africa, vii, 1900, p. 529.)

206. The coast belt of Dahome and Togo consists of alluvial laterite terraces alternating with banks of sandstone (? Cretaceous).

(D'Albeca, B.S.G., 1895, pp. 187–189; Toutée, A.G., 1897, p. 136.)

In the interior the denuded and eroded mountains of Nupe, Upper Dahome, the chains in the Togo and Eastern Gold Coast Hinterland, running generally north-east to south-west, Gurunsi, Baule, Koranko and the region of Karabe (Sirba) consist of Archæan rocks, granite, gneiss and mica-schists, partly covered by traces of sedimentary rocks, especially red sandstone and ferruginous conglomerates, which appear to extend over a large area, including the Mossi Plateau and the Say region.

(Gurich, M.P.G., 1887, p. 263; D'Albeca, B.S.G., 1897, p. 192; Toutée, A.G., 1897, p. 136; Wolf, M.D.S., 1888, p. 101; Chanoine, B.S.G. Comm., 1897, p. 752; Marcel Monnier, A.G., 1893–94, p. 417; Trotter, G.J., 1897, vol. x, p. 146; Barth, vol. iv, p. 271.)

207. From specimens brought home by von Zech, from the districts of Tappa, Krachi (Kratye), Adele, Apai, Achnte (Atyuti), &c., it appears that the neighbourhood consists of quartz, quartzites, clay-ironstone, with ferruginous sandstone and conglomerates.

(M.D.S., 1898, p. 157.)

208. Running north-east from the mouth of the Kribi is a narrow band of gneiss with laterite on either side of it. Immediately north of the Lukenye mouth is laterite, and just south of Njong mouth begins the narrow coast belt of alluvial sand, extending to the month of the Kamerun River, and backed by laterite reaching east to the schist mountains which run south from Lungasi Lake. An area of mangrove surrounds Kamerun River mouth. The Mangamba region is mica-schist, and to north of this is the great gneiss and granite district backing the basalt of the Kamerun Mountains.

(Knockenhauer, M.D.S., 1895, p. 87, map.)

209. The Chamba Mountains, to west of Faro River, are of granite. Between Tseboa and Gumna are mountains of sandstone in north and gneiss in south.

North of the junction of the Mao Kebi, and along the right bank of that river, extends a gneiss region, with porphyry. A large tract east of Adumre is gneiss.

South-west of Dalami is also gneiss, and so, too, is the district between the Sari Mountains and Faro River, in about 8° 30′. To the south of the Sari Mountains is a large plain with phyllites, amphibolites and porphyry.

Karna (south of 8°) is a basalt tableland, and the Muri district is a sandstone plateau.

(Passarge, M.D.S., 1895, p. 184, map.)

210. The Egyptian Sudan may be divided into two sections by the 13th parallel. North of this, berween Darfur and the Nile, is a sandy plain with rocky patches, a kind of steppe land; on the east of the river the country is quite different, the soil being firm and clayey.

South of the 13th parallel the whole region on both sides of the Nile is clayey and rich in humus; it is only sandy in certain detached localities. South of Kordofan are the mountains of Nuba with their immense valleys; to the south-east of Jezira the mountains extend to the south-west of Abyssinia. The vegetation is luxuriant in this region.

(Slatin, B.S.K, iv series 1895, p. 331.)

211. The vast extent of greyish and black rocks, which obstruct the Nile, beginning with the second cataract (Wadi Halfa), presents the appearance of a great development, by cataclysm, of basalt and granite. The appearance of basalt, however, is only on the surface, and the rocks are really a reddish granite. The banks here bristle with amphibolite and felspar, rising out of the sands.

The western route from Wadi Halfa to Dongola lies through an arid rocky desert; on the east side the soil is granitic.

At Samne the rocks are black amphibolite, with veins of white felspar and micaceous schists, with very little granite. The sandstone mountains of the neighbourhood rest on primitive rocks, and the soil on both banks is sand overlying granite.

From Samne to Ambukol the mountains become schistose and of a yellowish blue colour.

The Dosh Mountains are of sandstone.

In Dar-Dongola the sandy desert gives place to clayey fertile soil.

(Abbate, "Dongola et la Nubie," B.S.K., 1897, p. 745.)

212. Kibusi Hill (Kasoka), on the right bank of Victoria Nile, to south of Lenge junction, has its top strewn with large blocks of granite.

(Vandeleur, G.J., 1897, vol. ix, p. 374.)

213. On the Red Sea, in about 22° N., Jebel Shindeb is igneous. The central mass of Mount Erba (Elba) is granite. To the south and south-east of this are igneous rocks; to the north and north-west are shales, clay-slates and metamorphic rocks, with granite at Jebel Emoa and Jebel Maneht. The hills on either side of Wadi Gabeit are igneous, with deep veins of quartz.

(Bent, G.J., 1896, vol. viii, p. 344, and map.)

214. The Web River, 30 miles south of Ginea, carves its way through a mountain of quartz.

(D. Smith, G.J., 1896, vol. viii, p. 129.)

215. At Moghara (Maghara), on the road to Siwa, are sands and sandstones, also south of Siwa and elsewhere in the neighbourhood.

(Jennings-Bramley, G.J., 1897, vol. x, p. 397.)

216. The Bumban Hills, in Sierra Leone, are masses of granite.

(Trotter, G.J., 1897, vol. x, p. 240.)

217. The Shirwa Plain is an alluvial flat.

The lofty neck, separating the two southern arms of Nyasa, is composed entirely of granite and granitoid rocks.

(Moore, G.J., 1897, vol. x, p. 291.)

218. The southern half of Tanganyika lies at the bottom of a succession of great faults in a series of massive sandstones and conglomerates, which extend through the great elevated plain of Awemba as far as Nyasa and Angoni.

(Moore, G.J., 1897, vol. x, p. 299.)

219. The granite region of Mpamba Bay soon gives place eastwards to gneiss, which, sometimes with a surface layer of laterite, occupies most of the Wangoni country.

Further east the plateau between the Rufiji and the Ruvuma is chiefly sandstone. The sandstone region ends at Mohesi.

(Lieder, M.D.S., 1897, Heft ii, and map.)

220. The maritime plain near Berbera, known as the Guban, is a limestone country. The geological section exposed at Miriya Pass is typical of all the country south-east from Berbera to Bohotle; on a bed of gneiss rest some 1,800 feet of limestone, with less important layers of shale and sandstone. The band of hard limestone, some 250 feet in thickness, appears very generally over the country, and is eaten into caves at its outcrop. Habrje Peak is surrounded on all sides, except the north, by dense forest, the soil consisting of decomposed detritus of the intrusive rocks, which form the peak.

Some 10 miles to the north the plateau is bounded by gneiss hills.

(Parkinson, G.J., 1898, vol. xi, p. 15.)

221. At Tajura are cliffs of coral, succeeded by rounded limestone hills, the horizon being bounded by a peaked range of basaltic formation.

Jebel Gudah is of trachyte; west of this are undulating hills, covered with basaltic boulders.

West of Wardelihan are precipitous basalt cliffs, opening on to a plain of black lava, extending to Gubat-el-Kherab. Volcanic country follows, a limestone substratum occasionally showing through the lava.

On Gangade Plain is an alluvial deposit.

The hills bounding the Kurri Valley are composed of basaltic and porphyritic rocks, with occasional conglomerate and sandstone. South-westwards to Marba is a plain covered by

basaltic pebbles, the whole country round being basaltic and lava-covered, and extending past Dadu. Kumodali is a level sandy plain, cut by lava ridges. On Gobad Plain are basaltic pebbles. The Mari (Muri) Range is basaltic, and this formation is continued south-west with great sheets and reaches of lava. The Mullu and Halakdigi plains are alluvial. The hills near Hau are of wacke.

(Kirk, J.R.G.S., 1843, p. 221.)

222. The region south and south-west of Lake Tsana is volcanic. Zingini River, forming the boundary between Damot and Agaumider, flows among volcanic rocks.

Tummaha district shows unequivocal signs of volcanic origin, the fertile argillaceous soil being formed by the disintegration of the rock, which continually protrudes on the surface; the mountains consist of a mass of volcanic cones.

Fudi Mountain is the centre of a great volcanic district.

The Gudera–Agaumider–Assoa Range is of volcanic origin.

(Beke, J.R.G.S., 1844, pp. 7–12.)

223. On the Sabi River plain arenaceous limestone overlies bright red sandstone. At Longoneli's is a large tract of country with rich black soil, whose fertility is due to the presence of volcanic rocks, which are seen rising in small isolated hills. Umtonto district is greenstone-porphyry with quartz-gravel and quartz bands, and sandy soil with red clay on the hill sides. Beyond this the country is a succession of hills and valleys with red clay soil and porphyritic rocks.

(Erskine, J.R.G.S., 1878, p. 25.)

224. South of the Bahr-el-Zaraf the country on both sides of the Nile rises in alluvial plains.

The Blue Nile, after Roseires is passed, traverses rich alluvial plains extending for an immense distance.

(Garstin, Blue Book, Egypt (2), 1901.)

225. Namtitari (Natari) Hills, the first from the coast, are of granite, and thence westwards granite slate and boulders frequently appear, for 100 miles, as far as Shalawe Plain, with abrupt hills.

(O'Neill, P.R.G.S., 1882, p. 193.)

Immediately north of 14° N. a craggy granite chain, with precipitous peaks, runs northwards parallel with the coast.

(Thomson, P.R.G.S., 1882, p. 648, map.)

Nikoche Hills, situated in 12° 25′ S., 38° 28′ E., are of granite, surrounded by a vast waste of dried forest, with here and there great boulders of gneiss standing out. The ground is bare and arid, being merely a thin crust scarcely covering the solid rock.

(Maples, P.R.G.S., 1882, p. 79.)

All the hill ranges of the country traversed by O'Neill are without exception granitic. These include the Inagu, Namuli and Luasi masses, and all the hills of the Lomwe district, Chiga, Hibawa, Mrupa and the Luasi heights, as well as many other hills.

(O'Neill, P.R.G.S., 1885, p. 437.)

226. Between Rio Inhondo and Mopeia are clayey and sandy alluvial deposits; thence, parallel with the Zambezi, to Rio Mekumbo, are soft sands, followed onwards to the Shire River (along proposed railway route from Kilimane) by quartzose granite and basalt.

(Sarmento, "Carta do Delta do Zambeze," 1/500,000, Lisbon, 1891.)

227. East of Giraul the perpendicular faces of the high masses are covered with an efflorescence of almost pure sulphate of magnesia. This formation is succeeded by massive basalt. The narrow slip of basalt is followed by quartzose rock. This changes to quartzose granite and in some places to a fine-grained porphyry. After the ascent from Giraul, is a large second plateau covered with granite boulders. Pedra Grande is of granite. The country between the Serra Chelia and the Kakula River is sandy.

(Mayo, P.R.G.S., 1883, pp. 460, 464.)

228. At Kella the cliffs are of granite.

(Bruce, vol. iii, p. 113.)

Near Adowa, in Tigre, the soil is white clay mixed with sand

(*Ibid.*, p. 124.)

The soil of the wooded and cultivated country to the north of Gondar is red earth, and the bottoms of all the rivers are soft and earthy.

(*Ibid.*, vol. iv, p. 289.)

In Western Abyssinia, between 13° N. and 16° N., at least until the Atbara Deserts are reached, the soil is composed of black earth.

(*Ibid.*, vol. iv, p. 326.)

Godem district is granite and gneiss, with great beds of lava.

(Rholfs, "Meine mission nach Abessininen," p. 97.)

The Ambas, or elevated mountain plateaux, are of sand and sandstone in the north, though in the south they are of volcanic rocks, *e.g.*, Magdala.

(*Ibid.*, p. 166.)

To the east of Debra Tabor is a plain of humus.

(*Ibid.*, p. 196.)

North from Lamalmon run colossal basalt offshoots.

(*Ibid.*, p. 284.)

229. A plateau of Cape formation—diabase and dolomite—occupies the south of Bechuanaland, and gives rise to the peculiar flatness of the region; this is bounded on the south by Campbell Range running south-west and north-east. On the west this plateau merges into the South Kalahari. On the north and east it has no precise limits, ending where the gneiss and granite appear north of Mafeking. The middle and north of Bechuanaland form part of the accidented area of the Limpopo, bounded on the west by the Kalahari and on the north by the massif of granite and gneiss of the Matabele country. This boundary follows the Lotsani Valley and the Limpopo depression, *i.e.*, the great valley lying between the Limpopo and Zoutpansberg on the

one side, and the Matabele massif on the other. The Limpopo Plateau borders on the accidented (folded) country on the east. The Kalahari, the above-mentioned faulted and folded district, and the Limpopo Plateau are formed of fragments of the older formations, up to the Cape formation. In the first two regions there are gneiss, granite and sedimentary rocks, which resemble the Cape formation. The Limpopo Plateau is of Swazi and Cape formation.

It is argued that the Kalahari and Limpopo Plateaux once formed a single region inclining from east to west. This primitive mass was split up either by volcanic action or erosion so as to form a number of mountains separated by valleys, now occupied by the courses of the Notwane, Mariko and Limpopo.

(Laloy, B.S.G., iv, 1901, p. 270.)

230. The Didessa rolls down great blocks of basalt, but, to the west of it, quartz, porphyry and serpentine are the prevailing rocks, and, on the east, the quartz and granite begin to appear to the west of the Guder River.

(Le Roux, B.S.G., iv, 1901, p. 226.)

231. South from Casablanca for 25 kiloms., are calcareous rocks; south of this, for 30 kiloms., is the tirs or fruitful country, covered with a black vegetable soil, reaching as far us Mzamza Hills. The desert of Beni Meskin immediately north of Um-er-Rbia is calcareous.

(Weissgerber, B.S.G., iv, 1901, p. 235.)

232. The whole of the middle and lower Sassandra region is granite.

(Thomann, A.F., 1901, Supt., No. 6, p. 113.)

233. Between Tawa and Jibale the soil is sandy throughout, with sandstone in the valleys and old river beds; and at Zinder the granite appears.

(Peroz, R.G., ii, 1901, p. 469.)

234. On the plateau leading from Inyanga to the Zambezi–Pungwe parting the geological formation is similar to that of the country round Masikesse. Granite is visible only occasionally, the hills between the Gairedzi and Katandiga's being for the most part composed of talcose schist interspersed with quartz veins. Further north the kopjes and visible rocks consist almost without exception of banded quartzite with quartz reefs, and this extensive formation seems to be the matrix whence comes the alluvial gold found in the lower reaches of the streams running into the Zambezi.

From where the Muira leaves the hills the country for some miles is composed of deep rich vegetable soil.

(Arnold, G.J., xviii, 1901, p. 515.)

235. On the Zombo Plateau, east of San Salvador, the soil is very sandy and the country is well drained.

(Lewis, S.G.M., 1901, p. 578.)

236. The raised beaches at Dar-es-Salam consist of coral rock and consolidated fragments, overlaid by brick-red sands and clays, derived from the metamorphic rocks of the coast

range; in the upheaval of the coast there has been a pause, and two, if not three, beaches result (vol. i, pp. 75, 94, 134; ii, 300).

Mount Johnston is of lava intercalated between beds of sandstone (i, p. 148).

In Ukhutu are intrusions of basalt among the sandstone beds (i, p. 167).

From the Uchungwe Mountains (Uhehe) to Mkubwasanya, the underlying rocks are compact granite with occasional areas of volcanic rocks. After leaving the last-named place the granite becomes more felspathic and extremely decomposable, so that for a great depth it has been transformed into a sandy clay with huge blocks of rock, and this clay is cut into gullies 50 to 60 feet deep (i, p. 227).

The Nyasa Tanganyika Plateau consists of clay, slates, and other metamorphic rocks, except around north end of Nyasa, where the rocks are volcanic (see Note No. 2) (i, pp. 253, 315).

Round Pambete (South Tanganyika) are precipices of red jointed sandstone (ii, p. 2), and the same formation thence to Pamlilo (ii, p. 23).

In the neighbourhood of the Lukuga outlet are very soft and friable sandstones, and consequently the hills and surrounding country are very low compared with the rest of the lake region (ii, p. 67); and the Kitinga and Kichanja Hills consist of soft sandstones and shales, with coarser strata containing water-worn pebbles (ii, p. 107).

On Tanganyika, wherever the shores are low, they are found to consist of this soft sandstone; this is the case from Mpala to Mtowa, and from Kaboga to north of Ujiji, also in a small tract north of Kungwe and in the country about Manda and Iendwe. The Rivers Ruche, Malagarasi, Lofu, Lofuku and Lugumbu flow through sandstone areas.

The Uguha region is of soft sandstone (ii, p. 85).

From Kungwe to Mpimbwe the rocks are metamorphic, greywackes, schists and gneiss.

The red calciferous sandstones, shales, pebbled beds, occasional limestone strata, and even coal deposits, stretch from near the Equator to south of the Ruvuma, and probably even to the Cape, in a narrow but unbroken band, and may be regarded as carboniferous (ii, p. 301).

(Thomson, "To the Central African Lakes and Back," 1881, and map.)

237. The carboniferous area extends along south of Zambezi from Shangani River to Sanyati River, while, at the junction of the Umfuli with the last-named, there is granite.

Coal also appears to the east of Tuli.

(British South Africa Company's Report, 1899–1900, map.)

238. Between Duruma and Teita is a sandy reddish soil, due to the change from the shales farther east to coarse gritty sandstone (p. 68).

The above carboniferous rocks give place at Teita to metamorphic rocks, schists, gneiss, greywacke and hornblende (p. 72).

The Kilimanjaro lavas begin at the Lumi River (p. 115).

At Njiri is an outcrop of gneiss with a northerly strike and an almost vertical dip, and here the area of volcanic eruption, with Kilimanjaro as centre, ceases (p. 280).

Donyo Erok and Ndapduk are of graphic granite, gneiss and schists (p. 281).

At the Turuku nullah the metamorphic rocks disappear at a very high angle beneath the lava (p. 293).

At Gwaso Kedong begins the area of the later volcanic energy (p. 328).

A ridge of trachyte rock runs across the trough of Gwaso Giligli suggesting a lava flow from Buru (p. 347).

The trachyte rocks over which the Kekupe runs have been altered into a white soft rock resembling chalk in colour, weight and hardness (p. 349).

At the falls of the Ururu the rock is a very compact lava with a tendency to columnar arrangement (p. 376).

The lava of the mass of Kapte and Likipia are of older date than those of Kilimanjaro, Longonot, La-Nyuki and Buru, except on the east side of Likipia, where they are of the same date (p. 382).

Kamasia, forming an offshoot from the Mau escarpment, consists of a metamorphic rock composed of white striated felspar, a little quartz, and black mica in minute scales (p. 462).

Elgon is volcanic and rises out of the metamorphic rocks (p. 509).

(Thomson, "Through Masai Land," 1885.)

239. The centre of the Congo basin, through a whole stretch of the thousand miles of the navigable river and tributaries, is an alluvial plain rimmed in on all sides by rocky ridges.

(Hinde, G.J., v, 1895, p. 301.)

240. At Nyangi Rapids, south of the Makalli junction with the Lualaba, is quartz.

(Hinde, G.J., v, 1895, p. 439.)

241. Southward from Lusambo-Gandu extend the soft Lubilashi sandstones to the junction of the Lubudi with the Lualaba, and as far as Kabulubulu Falls.

The Museya district is of the same formation. Above the Kabulubulu Falls the Lualaba flows through a Palæozoic region.

Kundelungu hard sandstone lies between Mweru and the Lufili, tapering southwards to 11° S.

Manika Plateau is of the same.

A band of granite extends from west of the south bend of the Luapula, after its exit from Bangweulu, in a westerly and north-west direction up to 12° S.

(Cornet, M.P.G., 1894, p. 121, and map.)

242. Immediately south of Omdurman is sand, and south of Khartoum sand dunes.

(Schuver, M.P.G., 1884, p. 53, map.)

243. On each side of the Lower Limpopo alluvial patches form the beginning of those bush-covered and worthless limestone plains that fill up 90,000 square miles of this part of South-East Africa (p. 76).

The whole coast, from Natal upwards, is bordered by a ridge corresponding to the Berea at Durban. In places, portions of this ridge lie detached from the mainland and form islands. In Natal and throughout the Zulu country this ridge is backed by hills, rising step by step, to the interior; but from St. Lucia Bay northward towards the Zambezi, the whole country is a sandy (red sand chiefly, pp. 105, 107) flat, covered with bush, the mountainous country lying further away towards the interior, until the Limpopo is reached, when it is distant 200 miles from the coast. This coast ridge is formed of blown sand, and encircles the fertile soil of Inhimbane; but as a rule the vast plain may be characterised as a "mitigated desert." This great limestone plain of South-East Africa is hemmed in by mountains on the west, and is somewhat curtailed towards the north by an extensive spur thrown out by them towards the coast, and called Gorongosi, to the north of Sofala and near the Zambezi. It appears to extend north along the coast even to Abyssinia, being more or less broad in different localities (p. 85).

The Murgis flows directly into the Bosi over a bed of trap and serpentine (p. 96).

The Umswelizi flows over a bed of porphyry and basalt (p. 97).

South of the Sabi to the Limpopo is red sandy soil (pp. 105, 107). (See Note 174.)

(Erskine, J.R.G.S., 1875.)

The arenaceous limestone overlies a bright red sandstone in places. The remarkable deposits of lime become even more strikingly marked along the channel of the Sabi, where bluffs of pure lime and pebbles, 100 feet high, rapidly succeed each other for from 150 to 200 miles.

(Erskine, J.R.G.S., 1878, p. 27.)

Monjo country has a hard sub-soil with outcrops of limestone.

(*Ibid.*, p. 78.)

244. The soil of Akim between 6° and 7° N. in about 1° W. is heavy tenacious red clay, quartz veins and sandstone cropping up in all directions.

(Hay, J.R.G.S., 1876, p. 301.)

245. For the greater part of the way from Suakin to Berber are ranges of hills of volcanic origin and level tracts, which have evidently been the craters of long-extinct volcanoes with heaps of lava and scoriæ and trap dykes.

(Watson, J.R.G.S., 1876, p. 413.)

246. In Wassaw (Gold Coast), in some alluvial districts, the whole of the sandy gravel below the surface soil is auriferous.

At Tarkwa the dip of the reefs is about 45°, the head and foot walls being composed of syenite as hard as flint.

(Skertchley, J.R.G.S., 1878, p. 278.)

Most of the Wassaw ranges of hills are quartzose, especially towards the north, those to the south being more basaltic.

(*Ibid.*, p. 281.)

247. From Tati River to Bulawayo (38 miles) are stony hills with blocks of granite (p. 292).

Between Molopolole and Machudi the soil is a yellow sand (p. 292).

From Barkley to Taungs are sandy ridges with limestone (p. 288).

(Baillie, J.R.G.S., 1878.)

248. Mtuwa (near Mavuji River) peaks are metamorphic masses. The strata dip 40° towards the sea and strike north and south.

The neighbourhood is a rolling country with outcrops of metamorphic rock. There are also metamorphic rocks at Nakiu. Matu is a quartz mass.

Kitanda and neighbourhood are metamorphic.

(Smith, R.G.S. Suppt. Papers, vol. ii, pp. 109–113.)

249. On the Tomi River, in about 5° 45′, the soil is clay.

(Gentil, T.M., 1901, p. 541.)

250. The country between Bari, on the Webi Shebeli, and the Jub River is a sandy plain.

(D. Smith, G.J., viii, 1896, p. 131.)

251. Near Wurnu (Sokoto), and north of a Gandu-Wurnu line, is nothing but sandy soil with hard black volcanic rocks.

(Wallace, G.J., viii, 1896, pp. 216, 218.)

252. Along the Daua the strata are, generally, horizontal, and appear to represent old sea or lake bottom.

(Bottego, G.J., viii, 1896, p. 516.)

253. Going west from the parting between Nyasa and the Rivers Loangwe and Zambezi the granite ceases and gives place to shale and schist.

(Money, G.J., x, 1897, p. 158.)

254. Between the Chobe and the Okovango the country consists of dreary sand hills.

(Schultz, G.J., x, 1897, p. 175.)

255. At Obbia and northwards the coast belt consists of sand dunes with pebbles, rising gradually by terraces, on which the underlying rock is sometimes exposed. The predominating rocks of the neighbourhood are compact and calcareous, slightly crystalline, with calcareous sands in the depressions (p. 269). The plateaux on either side of the Kalule River are traversed by small calcareous ranges (p. 271).

North from Wadi Nogal the country is the same—rocky, calcareous, and argillaceous (p. 273).

(Bricchetti-Robecchi, B.S.G.I., 1891.)

256. The Berbera coast belt is sandy, but the volcanic rocks begin to appear a few miles south at Mount Guban.

(Di Vesmes, B.S.G.I., 1893.)

257. From Mogdishu northwards to Obbia is a narrow sandy coast belt (p. 359).

Inland from Elhur and Obbia is described as sandy with argillaceous earth and salt pans here and there (p. 362), Wad Oglov showing exposed the usual reddish cavernous calcareous rocks (p. 723).

Bannok Hills are of argillo-calcareous formation.

Between Hablei and Ellahelai stretches a desert of clayey sandstone reaching away both north and south (p. 819).

Westwards from Budir is a great plain composed of stiff red clay, called Dibir Plain (p. 822).

West of Elgut the soil begins to have an alluvial appearance (p. 825).

West of Warandi the soil is argillaceous and arenaceous (p. 826).

Beraharago Plain is of red calcareous rock (p. 826).

West of this at Badhovwein the rock is still calcareous (p. 827), and is continued westwards as the prevailing rock (p. 832), and is in places very stony (p. 835), in others clayey with calcareous detritus (p. 836).

This calcareous formation is continued to Gurel, where it changes, and onwards to the west is compact argillaceous conglomerate (pp. 836, 837, 839) overlying red calcareous rocks (p. 841).

Near Darerto, near the Webi Shebeli, are alluvial meadows (p. 962), and also alluvium along the river (p. 967–8).

North of Barri the mountains and plateau are of the accustomed calcareous type (pp. 973, 974).

Godajarre (God-la-yare) Plain is entirely alluvial (p. 978). See Nos. 17, 18.

The soil in the valley north of Habale (south of Hargeisa) is argillo-calcareous mixed with sand, and formed of the detritus of the calcareous rocks of the plateau (p. 987).

(Bricchetti-Robecchi, B.S.G.I., 1893.)

258. About 12 miles west by south of Horoabdullah (Somali), and just south of 8° N., is a volcanic crater.

(Pease, G.J., xi, 1898, p. 138.)

259. South and south-west of Ngami are two principal formations: the Maseganite (Palæozoic quartzite) strata strike in a curved line from west to east-north-east and north-east, and a volcanic line of hills (quartz and porphyry and greenstone) runs in a parallel direction.

Near Reitfontein the strike is from north-north-west to south-south-east, and corresponds with the direction of the terraced scarp of the Damara highlands.

The Maseganite occupies a wide area.

There are no horizontal strata, but there is a recent surface formation of limestone. This area is being rapidly converted into a sandy waste.

(Passarge, G.J., xi, 1898, p. 181.)

260. The Nyasa shore (in Angoniland) slopes gently for from 15 to 20 miles to the foot hills of the Kirk Range, where the land rises abruptly from 1,600 feet to a plateau 4,000

feet above sea level, studded with granite peaks rising to 6,000 and 7,000 feet.

(Codrington, G.J., xi, 1898, p. 509.)

261. In the Choma district (Mweru) the ground looks like clay half burned into red brick, and there is, in places, what looks like iron slag. The south cliffs of Kilwa Island are the same. All this country seems to speak of great heat and upheavals of nature.

(Croad, G.J., xi, 1898, p. 620.)

262. Mchinga Range (west of Loangwa River) is composed of granite. From Chilenga's to the Chizimba River the country is all granite; after crossing this, it suddenly changes to schist. Katiso is a granite kopje.

(Hoste, G.J., xi, 1898, p. 625.)

263. The first 15 miles of coast is a bed of sandstone (*i.e.*, inland from Pemba Bay), which reappears inland at the lower end (*sic*) of the Lujenda, at the north end of Nyasa and on its north-west shores; this is the coal-bearing stratum. It is argued from this that a coal belt runs a little north of 13° at the coast, and runs north-north-west from the north of Madagascar to the interior of Africa.

After these 15 miles the whole formation varies, and gneiss and granite run uninterruptedly right away to the mountains on 15° Lat.

Near Medo, and again on the Luambala, are intersecting veins of a very compact and heavy carbonate of lime.

(Spilsbury, Journal of the African Society, No. 1, 1901, p. 136.)

264. Gabbro appears near Monrovia. Near Akra is coarse-grained intensely red and somewhat argillaceous sandstone, with intercalated layers of quartz pebbles.

Further inland are gneisses and granites, while in Ashanti and along the Volta are fine black amphibolite schists.

(Lenz, Geolog. Mag., 1879, p. 172.)

Sixty miles inland up to the Ogowe River, the Okande district is composed of iron mica schists (*ibid.*).

265. The horizontal tertiaries of the Loango coast are overlaid by loam (*ibid.*).

266. Going north from Grootfontein (in about 19° 30′ S.) the limestone formation ceases just to the north of Tsebib and gives place to the red sand.

(Volkmann, D.K., 1901, p. 866.)

267. The Lebompo Chain is eruptive.

(Molengraaff, A.G., 1901, p. 450.)

268. The rock specimens collected by Johnston, Wilson, Racey, Grant, Hobley, Isaac and others include Archæan gneisses, schists and granites, which constitute the main mass of the Uganda Plateau; specimens of these rocks come from Busoga, Bukedi, Elgon and Unyoro districts, from Ruenzori and the Nile province. Besides these basement rocks there are specimens of ferruginous, schistose and slaty rocks from Unyoro, possibly belonging to the Palæozoic

Karagwe series; coarse ferruginous sandstones and quartzites from the shores of Victoria Nyanza and Lake Naivasha and from Ankole, and volcanic rocks (chiefly phonolites) from Kavirondo, Mount Elgon, Baringo district, Kamasia Hills, Lake Nakuro and the Nandi district.

(G.J., xix, 1902, p. 43.)

269. A band of the Karagwe (Palæozoic) beds extends from the north of Tanganyika northwards, expanding as it goes north, and, curving round the volcanic mass of Virunga, reaches almost to the shores of Lake Albert Edward on the west, while its eastern limit runs parallel with Lake Victoria up to the Kagera Mouth.

North and south of Lake Albert Edward is alluvium, and from the north corner of the lake a volcanic band runs north (Ruenzori).

(Gregory, Qr. J., 1895, p. 669.)

270. Nearly the whole of the interior of Spanish Guinea and the neighbouring parts of French Congo are covered by a thick layer of fairly soft impermeable red clay. It is certainly over 2 metres thick, and all the banks of the rivers are of the same material. Mixed with the clay is found quartz, especially towards the sea in the Monts de Cristal Region.

(De Mézières, A.F., 1902, p. 23.)

271. Western Gurara, the depression of the Twat oases and the northern and western portions of the Muidir Plateau are all Devonian.

(Flamand, A.F., Supt. No. 1, 1901, p. 32.)

272. In Dahome, behind the littoral zone, is laterite, derived from various rocks and at different periods.

At Zegnanado the laterite rests on a bed of granitoid gneiss.

Almost all the Dahome Mountains are composed of gneiss, and the plateau of Paraku is of the same formation.

(Brousseau, B.S.G., 1902, p. 67.)

273. In the immediate neighbourhood of Kilimanjaro and Meru the rocks are of the younger eruptive class, but on either side of the Graben they are older.

(Shoeller, "Aequatorial Ost–Afrika und Uganda," Berlin, 1901, with map.)

274. In Natal, from the coast inland for 13 miles, we have first Dwyka conglomerates for 5 miles, between two dykes of this being Ecca shales; west of the second dyke are conglomerates again, overlying Table Mountain sandstone, which crops out further on. After passing the Umzimkuluana–Umzimkulu Junction there is marble, followed by granite and débris.

(Draper, Qr. J., 1895, p. 51.)

275. Badattino district, between Addis Abbaba and the Blue Nile, is basalt (p. 15).

The lake region (Zwai, Hora, &c., to Abbaya) was a great diluvial basin. The prevailing rock of the hills is Obsidian with other volcanic rocks.

The district between Harar and the Webi River is middle Jurassic. There are Jurassic strata at the foot of Abdulkassim on the Dolol-Ja (Upper Webi) and also traversing the Badattino basalt beds.

In Gillet Mountains (Upper Webi) and between Abunas and the Webi are Cenomanian and Turonian (Cretaceous) deposits, both overlain and underlain by eruptive rocks.

Abulkassim, the Hawash Valley, and thence up to the Blue Nile are younger eruptive, and all the country west of the Graben as far as Gurafarda Mountains (Gelo River).

There are gneisses and quartzites in places on the Blue Nile and Omo.

In portions of Ennia Gallaland (between Harar and the Webi) young freshwater fossils were found, and also in the Graben (p. 31).

(Neumann, Z.G.E., 1902, p. 7.)

276. Limestone extends in a narrow band from Tembue Bay (Tanganyika) in 6° 30′ southwards, almost in a direct line into Marungu, immediately to the west of 29° 30′, and reaching almost as far as 7° 30′.

(White Fathers, M.P.G., 1902, p. 13, map.)

277. Between Cape Delgado and Kilwa Kisiwani exteuds a band of Tertiaries and alluvium. On 10° S. are Cretaceous (? early Eocene) beds.

South of this the Tertiaries fine off towards the west and terminate in 36° 35′ (about).

A similar block of Tertiaries extends inland from the coast, between Kilwa, Kisiwani and Bagamoyo, reaching as far west as 37° 25′ (about).

There is a band of Jurassic age near the coast, cropping out from among the Tertiaries somewhat north of 9°.

Karoo formation appears near the intersection of 8° S. and 38° E., and again to the east of Nyasa, eastwards of 35°, and about midway between 10° and 11° S.

(Bornhardt, "Zur Oberflächen-Gestaltung und Geologie, Deutsch-Ostafrika," Berlin, 1900, map.)

278. The mass of the Great Atlas of Marocco consists mainly of the primitive rocks and Palæozoic formations, together with Triassic, and, around these, on the west, north and east, are the later Secondary rocks.

(Rolland, "Géologie du Sahara algérien et aperçu Géologique sur le Sahara," Paris, 1890, p. 255.)

279. In the Nile province of the Uganda Protectorate, Chua, Lira and Kiteng, north of Aswa River, are granite chains.

A singular feature of the province is the occurrence of isolated granite hills.

(Delmé-Radcliffe, verbal information.)

280. At Msuwa (German East Africa) the country begius to rise, and outcrops of granite and quartz show through the soft red sandstone. The Kungwa Hills and Duthumi Hills are a mass of mountainous granite and quartz elevations (p. 286).

The Usegara Mountains are a mass of granite peaks (p. 287) and quartz, overlain in some places by red sandstone (p. 289.)

Mukondokwa Valley is bordered by lofty hills, surmounted by peaks and blocks of granite and gneiss (p. 290).

From Lake Ugombo to the Mukondokwa-Lufiji parting the soil is barren sand and gravel of quartz and granite overlying clay, with granite boulders cropping out (p. 291).

The Mpwapwa Hills are almost entirely of granite (p. 292).

The hills of the Marenga M'Kali Plain are granitic (p. 292).

Ugogo has a dried-up aspect, and consists of sandstone, in some places overlaid with a stratum of clay, with occasional huge masses of granite (pp. 292, 293).

Between Kanyenye and Useke is a chain of hills of masses and boulders of granite (p. 294).

The soil of Mdaburu Valley is a rich red loam (p. 295).

West of this, sheets of granite appear in the hill sides (p. 296).

At Marwa numerous boulders and granite hills stand out from the plain (p. 297).

South-west from Unyanyembe the rocky hills cease, giving place to a broad alluvial plain (p. 299).

Kawendi Mountains, on west of Ugara, are principally of granite, but patches of sandstone and immature clay-slate are also seen (p. 300).

Ras Mpimbwe (Tanganyika) consists of blocks of granite. The land in the neighbourhood is a soft light red sandstone, with masses of granite and hard sandstone embedded in it, the whole country at one time having apparently been a great lake (p. 307).

The mountains and hills between Tanganyika and the Lualaba are composed of granite, gneiss and quartz, with here and there patches of porphyry, the country presenting the appearance of having been the bottom of a great sea. The plains consist of rich red sandy loam, and in the watercourses are grey shaly sandstones. Near the Lualaba the country is composed of sand and water-worn pebbles (p. 312).

Beyond the Lualaba, and all along near the Lomami, the country is level, and consists of light yellow sandstone resting on granite. Kilimachio Hills form the west extremity of a system of granite and gneiss mountains, extending to Mweru (p. 313).

From Kilenga (Kilemba) to Lunga Mandi are flat-topped tablelands of sand. Usambi country is the same. Light sandy plains stretch from Ulunda right across Lovale (p. 316).

Bihe is formed of wooded hills of red sandstone (p. 317).

In the west of Bailunda are needles and cones of granite (p. 318).

(Cameron, "Across Africa," vol. ii.)

281. The neighbourhood of Lake Busumchwe, 25 miles south-east of Kumassi, consists chiefly of talcose and quartz schists, with intrusive bosses of granite, and shows no signs of volcanic action.

(Fergusson, G.J., xix, 1902, p. 372.)

282. Badinga and the neighbouring mountains, lying to the east of the Shari region, are of granite, rising out of an alluvial plain.

(Lamothe, B.S.G., v, 1902, p. 161.)

283. The whole region of the Upper Shari is Archæan, consisting of granites, with gneiss, micaceous schists and quartzites, the soil being ferruginous clay.

(Bruel, B.S.G., v, 1902, pp. 165, 166.)

284. Going south from Zeila to Bia Woraba there is first a coast belt of coral banks, mixed with sand. Then a belt 24 kiloms. broad of metamorphic rocks, then trachyte, basalt, and younger volcanic rocks for 180 kiloms., from Dadab to Gildessa. This is followed by crystalline schists and red granite, while to the east is Jurassic limestone.

(Paulitschke, "Geologische Routenkarte für die Strecke von Zejla bis Bia Woraba, 1/1,000,000, mit begleitvorten"; Mitteil. Geogr. Gesells., Wien, 1887, xxx, p. 212.)

285. From Gule, southwards to Keili, the country between the Blue and White Nile is of recent igneous formation, some of the hills being true volcanic craters. The far greater number are granite upheavals, and between these hills the plains are covered with soil to a great thickness.

(Digby Jones, I, 3(c), No. 88.)

The great plain extending southwards of Khartoum to Lat. 9°, is of Nubian sandstone of a tabular formation, the strata being horizontal. South of 9° to 6° is red Bunter sandstone, with blocks of granite. Here and there the sandstone is covered by limestone.

(Pruyssenaere, M.P.G., Ergan, No. 50, 1877, p. 12.)

286. The east and north-east of Darfur are granites, except between Foja and El Fasher, where there is sandstone in the neighbourhood of the water. The mountains in the neighbourhood of Wadi Millet are gneiss, and, north-east of this, granite is the prevailing rock. Jebel Tagabo is sandstone. Jebel Medob and neighbourhood are of volcanic origin. Bir-el-Malha, in the south-west of the mountains, is a volcanic crater. South of Massah is a rich alluvial plain, and south of 12° there is not a stone to be seen. There is an island of sand dunes between Darra and Sekka. (See Note 8.)

(Mason, M.P.G., 1880, p. 378.)

287. In Lagos the first stones met with going north from the coast are some 8 miles north of Agbabu, which lies in 6° 34′ 55″ N., 4° 50′ 37″ E., and are red granite. Between Iseru and Ajue is rough sand with gravelly subsoil. The Idanre Mountains are of granite and gneiss, with intrusive dykes.

(MacGregor, Copip 26,701, 1901–2.)

288. In Senegal, in the Bambuk district, the massive crystalline rocks appear as islands with a general north-north-west to south-south-east direction; amphibolite schists near

Kenieba, shales covered by sandstone in the central part of Bambuk (left bank of Faleme River), talc-schists and quartzites on left bank of Faleme and Senegal Rivers, south of Bakel; a vast deposit of laterite from 52 to 20 inches thick.

(Boudariat, Comptes Rendus Ac. Sci., 1902, p. 495.)

In the Kita district, comprising the country between the Bafing and Baule Rivers (Upper Senegal), the mountains are of sandstone, granite and ironstone; the soil of the plain being composed of clays and sands. Kaarta is flat and sandy.

(Tellier, "Autour de Kita," Paris, 1902, p. 20.)

289. In the lower Congo region, the coast district nearly up to Boma stands 100 metres above sea level, and displays in the following order, from the surface downwards, sand and clay, limestone, sandstone. From Boma to Mussuk, granite and crystalline schists. From Vivi to Ngoma, crystalline schists, quartzites and amphibolite, with veins of quartz. Lying unconformably on these, and extending as far as Long Reach, conglomerates, schists (Grünglanzende Schiefer), quartzites, grey schists (Graue Schiefer), with diabase faulting at Isangila. From Long Reach to Chambon Falls is a limestone and schist region (Kalk-und Schieferzonen). Then follows the horizontal sandstone of the interior, fine grained as far as Leopoldville, and coarser farther east. In the neighbourhood of the Pool and eastwards is a series of conglomerates, with brown and white sandstone and brown quartzite.

(Dupont, "Lettres sur le Congo," Paris, 1889; M.P.G., 1890, Litteraturbericht No. 407, p. 32.)

290. The country from Ferrad towards Harar is strewn with obsidian, silex and sandstone.

(Du Bourg de Bozas, R.F.E.C., xxvii, 1902, p. 244.)

291. In the littoral mountains of Eastern Algeria the Archæan rocks occupy an important place, and the eruptive rocks also, as well as the Eocene sandstone (Numidian). South of the old rocks is a secondary chain, with islands, as it were, of calcareous Lias, which forms the tops of the heights. The Kabyle of Jurjura consists of gneiss and mica-schist, while islands separated by Tertiary belts extend westward. The Kabyle of Babors is a prolongation of Jurjura, and is separated from the Cretaceous chain of Biban by a Senonian depression, the heights as before being crowned with calcareous Lias. The Kabyle of Kollo, extending between the meridians of Jijelli and Bone, is cut up by transversal Eocene zones; the western portion of this region is Numidian sandstone overlying Archæan rocks; in the east, Numidian sandstone lies to the north-west of the Archæan rocks; Cape Fer is eruptive.

To the west of Algiers there are only traces of the Archæan rocks, such as the Buzarea and Senwa peaks. There is, a line of Lias-capped eminences of shales extending

from the Maroccan frontier to Blida. Between Figalo and Oran are rhyolite and andesite; Murjajo massif is composed of schists and quartzites, almost perpendicular and very folded, but the summit is of dolomitic Lias; on the north slopes is lower Miocene (sandstones and marls), overlaid by the Pliocene plateau; on the south slope is upper Miocene (calcareous). East of Oran is Pliocene. The plateau zone north of Shelif is Miocene and Pliocene. Cretaceous chains extend north of Zakkar, the dome of which is a mass of schists and conglomerates (Permian). This formation of old schists with calcareous rocks is also found in Arib and Jebel Dwi. The Blida region is folded and contorted, the schists sometimes even overlying the Miocene.

Between the coastal mountains on the north and the chains of Tessala and Beni Shugran, Mounts Teniet and Boghar, &c., on the south, is a great Tertiary depression.

(Ficheur (A B and E), A.G., 1902, p. 221.)

292. In Algeria the Archæan and eruptive coastal mountains are surrounded, in the extreme east, by Eocene and Oligocene beds; then south-east of Algiers by Miocene, which also extends in a belt from the neighbourhood of Batna generally parallel with the coast westwards to Tlemsen, and continued in a great curve thence along the Sbu Valley and northwards almost to Tangier. This belt surrounds the Cretaceous of the Warsenis massif, that of the Biban chain which extends westwards, passing south of Blida and reaching the coast between Shershel and Tenez. Almost the whole of the Saharan Altas is lower Cretaceous, changing to middle and upper (chalk) in the north-east. South of the Miocene belt extends a band of Jurassic rocks, reaching from about 2° 30″ E. to the Mulwia on the west, and expanding to a width of 100 kilometres in the centre.

West of Melilla are crystalline schists.

(Blanckenhorn, M.P.G., Ergan 90, 1888.)

293. Between El Fasher and Khartoum are outcrops of granite or gneiss.

There is also limestone in the neighbourhood of Khartoum.

(Talbot Pasha, verbal information.)

294. The soil in the neigbourhood of the Ajibur River (tributary of Akobo R.) is of a gravelly nature (6° 43′ N. 34° 30′ E.).

Further south on the spurs of the Boma Hills it is red loamy clay.

The Sacchi River has worn great ravines from 30 to 50 feet deep in the soft clayey soil.

The Turkwell River flows through a sandy desert.

(Austin, S.G.M., 1902, pp. 286, *sqq.*)

295. The plateau on which San Salvador is situated is composed largely of ironstone, but limestone is plentiful a few miles from the town.

(Lewis, G.J., xix, 1902, p. 545.)

296. Near Likabula in Awemba country (near Chambezi River) is slate (schist).

(McKinnon, G.J., xix, 1902, p. 604.)

297. A rich limestone underlies the whole country in the neighbourhood of Kapopo Station on the Kafue River.
Near Sitanda the soil becomes sandy.
(Selby, G.J., xix, 1902, p. 606.)

298. Coal and copper have been found on the Cheredzi and Sabi Rivers, the former in the sandstone.
(Hyatt, G.J., xix, 1902, p. 637.)

299. In Shoa, Aubry and Douville (B.S. Géolog. de France, xiv, p. 201) found a grey marly calcareous formation, probably Bajocian (lower oolitic), overlain by yellowish crystalline calcareous rocks, probably Bathonian; and Blandford (*Geology of Abyssinia*, 1870) found a similar formation 400 kiloms. further north at Antalo (De Lapparent, p. 1020).

300. Immediately after leaving the hills of Dar Nuba and thence to the Bahr-el-Arab and Kir River, in a south-south-west direction, is a vast level plain with black cotton soil, with sand and gravel here and there.
Merekeb, 18 miles south-west of El Obeid, is crowned with limestone.
(Wilkinson, I. 3. c/111.)

301. In Liberia, within 35 miles of Monrovia, large deposits of graphite, iron, and gold-bearing quartz occur, while coal is found within 4 miles of a navigable river, about 25 miles from the port.
(S.G.M., 1902, p. 323.)

302. The valley of the Luama (Congo tributary) is granite, with clay and sand. The country east of Nyangwe-Kasongo is chiefly clay.
(Borms, B.C., 1902, p. 256.)

303. In the Tarkwa Gold-field the following formations occur in stratigraphical order:—
B. Clay-slate formation—
Sandstone, fine-grained, green and white, not thick.
Clay-slate, over 1,000 feet thick.
Sandstone, fine-grained, green and white, very thin.
A. Banket formation—
Consisting principally of sandstone, more or less coarse, quartzite, conglomerate, more or less auriferous, slate, not more than a few inches thick, and some calcareous beds.
Immediately north and west of Tarkwa and Atanash occurs the clay-slate formation, and, north-west of this, green sandstone. Along the Ankobra River, north of Awudwa, is sandstone and quartzite with numerous thin white quartz-veins, and parallel with this and further south-east is a dyke of hornblende, diabase, with a few beds of red slate, reaching from the Ankobra to Anakasa. North of Bonsa are micaceous and quartzitic and other sandstones, and veins of chlorite.
(Sawyer, Trans. Federated Inst. Min. Eng. 1901–02, xxiii.)

304. The Eritrean coast zone consists of a coral fringe backed, at a distance of a few metres, by low sand dunes of recent

formation. This zone is only 27 kiloms. broad between Massaua and Saati, and even less towards Zula, but expands to a considerable breadth in Danakil. North of Massaua it is between 30 and 40 kiloms. broad. On this coastal plain (Samhar) are, here and there, knolls of volcanic origin rising to heights varying from 20 to 100 metres.

(Saint-Yves, B.S.G., vi, 1902, p. 475.)

The coast at Massaua is limestone and madripore formation, but soon begin the gneiss and crystalline schists (p. 127)

At Magdala is volcanic rock (p. 168).

Guna Mountain district is basalt (p. 200).

Lamalmon and neighbourhood are huge basalt masses (p. 284).

(Rohlfs (a) .)

305. The Gundafi (Wuntaffi) region of the Maroccan Atlas is composed of friable blue Silurian schists.

(Doutté, B.S.G., v, 1902, p. 496.)

306. In Dar Banda, between 21° and 22° E., and 8° and 9° N., the Bere Bere massif overlooks a vast tract of sand.

(Pierre in Montrozier, p. 210.)

307. The whole of the M'Bomu region, including Dar Banda, and the sultanates of Bangasso, Rafai and Semio, consist of mica-schists and gneiss, with clay in the valleys.

(Montrozier, p. 264.)

308. The lower Eocene limestones and clays begin at a line drawn roughly north-east to south-west through El Borga. From El Borga a narrow band of marls and clays (? Danian) extends southwards, skirting, on the east, the upper Cretaceous limestone (? Danian), which extends northwards to the Eocene beds.

In the oasis of Kurkur are patches of calcareous tufa and conglomerates, surrounded by the Cretaceous limestone. Between the band of marls, &c., and the Nile is Nubian sandstone, and also on the further bank. At Assuan and southwards to Dabrok is a district of granite and gneiss, and a similar though smaller patch occurs at Kalabsha.

(Ball, "Reconnaissance Survey of Jebel Garra and the Oasis of Kurkur," Cairo, 1902.)

309. The rocks forming the first cataract (Assuan) are eruptive, syenite, granite and porphyry, all being manganesiferous. At the second cataract (Wadi Halfa) the rocks are ferruginous sandstone, also highly manganesiferous. It is this manganese which gives the black appearance to the rocks.

(Lortet and Hugounenq, M.G., 1902, p. 413.)

310. The country south of Gwikora (on the Wam River) is granitic.

(Löfler, A.F., Supt. No. 6, 1902, p. 122.)

The Tari Mountain region, north of Gwikora, is also granitic (*ibid.*).

The Baria or Ba, between 7° and 8° N., is encumbered with blocks of granite.

(*Ibid.*, p. 123.)

311. The soil of Jubaland is mostly sandy, interspersed occasionally

with patches of what looks like black cotton soil. At Ghulime the sand changes to disintegrated quartz.

(Cook, I. 3 c., No. 160.)

312. Near the Zambezi, between the Muira and Tete, is Trias.

(Peters, p. 58.)

The whole Senlangombe district is granite.

(*Ibid.*, p. 141.)

Katerere neighbourhood is also granite.

(*Ibid.*, p. 149.)

313. In Sierra Leone, to the west of Surunumia, between Karima and Kaballa are granite hills 500 feet high, and also on the route between Koinadugu and Kruto.

(Kemball, I. 3 c., No. 123.)

314. Grootfontein is situated on a limestone plateau.

(Jodka, D.K., 1902, p. 524.)

315. Near Cape Town are found granite and dolerite, probably of pre-Silurian age, and thence right away to the tropics Plutonic masses, dykes and lava flows interrupt the continuity of the sedimentary deposits with astonishing frequency. Sandstones of (?) Tertiary age rest unconformably on the Bulawayo schists, and the marginal portions of the Matoppo granite mass, which forms the backbone of Southern Matabeleland.

(Mennell, Geolog. Mag., No. 458, August, 1902, p. 356.)

316. In the Karoo formation the strata are horizontal (slightly inclined on their southern verge), and are traversed and overlain, but not much distorted, by frequent trap dykes. The Karoo formation consists mainly of alternations of shales and sandstones, of lacustrine origin, as pointed out by Bain and others. There were wide-spread terrestrial conditions during the Permo-Triassic age. In Cape Colony, on the Sunday, Zwartkops and Gamtoos Rivers, there are Jurassic strata, and traces of similar rocks are found higher up the coast near the Zambezi, and far down on the south and west in the George district.

(Jones, P.G.A., iv, No. 8, 1876.)

317. **Gambia.** What is said with regard to Senegal in para. 34 may be taken to apply, to some extent, to Gambia. On either side of the Gambia River there is for the most part a fertile but light sandy soil; here and there are small hills of laterite which, from Ballanghar on the north bank, and along all that portion of the south bank from close to where the Vintang Creek joins the river to the boundary east of Yarbutenda, take the form of a low ridge varying in height and situated at different distances from the river though following, as a general direction, its course. Laterite is the only kind of rock noticed in the Gambia territory and it is probable that no other exists.

(Communicated by Governor Denton).

318. **Gold Coast.** Sandstone is the principal rock of the Gold Coast hinterland; eruptive rocks are abundant, chiefly

NOTE.—Nos. 317 to 329 were noted or communicated subsequent to or in reply to the circulation of the proofs.

lava and scoriæ, but metamorphic rocks are rare. The rocks brought down by the Volta, from its course north of Daboya, indicate that in some parts of the district there are to be found clay, slate, quartzite, obsidian and gabbro. Rock-salt is said to be found in Pampamba country.

Nitre occurs at Bole and also at Massina. Gold is abundant west of the Volta, and Lobi district is especially rich.

East of the Volta clay-ironstone is frequently observed, the outcrops being detached. Iron is smelted in Dagomba, Pampamba, Buem, Kotokori, Gurma and Mossi. In these countries the prevailing rocks are sandstone and shale.

Between Adere River and Boniape, near the Volta, is sandstone (with a little mica in it), with a strike of 250°.

At Boakipe is yellow sandstone and at Bambusa and Fingbo, or Fumbo, grit and sandstone. Here the geological formation changes and decomposed granite, white mica, and red felspar occur. At Yakomba is an auriferous vein.

Between Kabalima and Gaepe volcanic scoriæ and lava were observed. At Grupe is granite.

In Gonja, at Kananto, in 9° 15′ N, is micaceous sandstone, with heaps of quartz pebbles. The Loru or Moli River has sandy banks.

At Kossu, in 9° 12′ N, 0° 53′ W, is sandstone, with intercalations of clay, furnishing springs, and many places are covered with scoriæ.

In Dagomba, on the Daka near Yendi, are unaltered sandstones. The undulations run east and west. At Chana is sandstone.

In Atabubu, near Prang, the Pru River has sandy banks but a rocky bottom.

(Ferguson).

At Pong (Kpong), near Akure, there is limestone. Between Wa and the Lobi mountains are granites and gneisses.

(Verbal information).

319. **Gold Coast.**—Geologically the Gold Coast Colony and Ashanti consist of two main areas, separated by a lesser, which forms the chief watershed of the country.

The latter, a comparatively narrow belt of regional metamorphism, is defined by the Akropong, Akim, Begoro, Kwahu and Mampon hills and the sandstone plateaux of Nkoranza, and terminates in Gaman. This belt has an average height of 1,200 feet, and in its centre, in Kwahu, reaches some 2,000 feet above the sea. Its rocks comprise sandstone, basalt, coarse gneiss, and granite, the latter two of which have by decomposition formed the alluvium of the valleys, where thick veins of quartz are frequent.

The two main areas consist of the open plains of the Volta basin on the north and east, and of the undulating forest country, an area of some 12,000 square miles, drained by the Tano, Ankobra, Pra, Birrim, Narkwa, Ainsu and Densu Rivers on the south.

319 (*contd.*)

The first of these areas comprises a country in which horizontal strata of sandstone and shales predominate, as in Kwahu. With this formation is found, through Atabubu and Nkoranza (the former slightly undulating and featureless), a fairly rich alluvial soil. The immediate neighbourhood of the Black Volta consists of—

(*a*) Volcanic agglomerate, forming gentle undulations—in places steep and rocky—from Tintankru to Akrosu;

(*b*) Indurated slate and shales from Akrosu to Nkami, where towering peaks occur;

(*c*) The same formation with quartzite from Nkami to Mem;

(*d*) Quartz from Mem to Senki, where precipitous hills are obstacles not only to road construction, but also to the navigation of the river; and

(*e*) Granite, gneiss and schist from Senki to Kpong.

The Volta basin has an average height of 450 feet, and falls between the Afram and Sene Rivers to some 380 feet above the sea.

The southern area of volcanic activity and contact metamorphism consists of—

(*a*) Crystalline rocks, in which mica and other schists and gneiss are associated with granite and other massive rocks, as in the valley of the Pra, and at Insuaim, and Animaboe; and

(*b*) Of sedimentary rocks, such as sandstone and variegated shales about Elmina, pebbly sandstone at Animaboe, slate beneath conglomerate beds around Tarkwa, sandstone and shales at Akra.

The shining mica and scoriæ of Animaboe and Agemna, and the broken masses of lava in the argillaceous covering of the Cape Coast hillocks testify to the former volcanic activity of this area. The valleys vary from 300 to 700 feet in height above the sea, and are divided by numerous hills and ridges, some 300 feet higher.

The soil, consisting of red and yellow clay (the result of disintegrated granite and of ferruginous red ore and non-ferruginous or yellow sandstone) and of black mould (the produce of vegetable decomposition), is generally very fertile, particularly in the forest zone; but the country between the Afram and Sene Rivers, and the plains between Akra and the Volta are sandy and unproductive.

It is believed that the whole of the Gold Coast is slowly rising, a view which is supported by the form of the cliffs along the shore; by the non-encroachment of the sea on a coast constantly beaten by the heavy Atlantic surf; by the variations in the course of the Pra, and by the rapids in it and the Volta, which indicate that these rivers cannot excavate a channel as fast as the ground rises; by the presence of marshes on elevated ground; and by the occasional occurrence of earthquakes.

320. **Lagos** (Colony and Protectorate).—The following is a general summary of the results deduced from an examina-

320 (*contd.*)

tion of a collection of 205 rock specimens, consisting principally of schistose and plutonic rocks.

The most abundantly represented rock was gneiss, of which there were several varieties. The majority were coarse-grained, with a fair proportion of medium and fine-grained types. The leading variety was biotite-gneiss (a foliated aggregate of quartz, felspar, and biotite). Muscovite was sometimes associated with the biotite, and in some specimens, hornblende replaced the biotite. A common feature of the coarser gneisses was the presence of large *phacoids* of felspar. In a few specimens garnets were common.

Of upwards of twenty specimens of quartz-rock or quartzite—some were white, others more or less discoloured with ferruginous and other impurities. Most of them showed distinct evidence of "shear," and were more or less foliated, showing scales and crystals of such minerals as muscovite, diallage, tourmaline, &c.

Next to gneiss, granite was the most abundantly represented rock in the collection. Some of the granites are medium grained, but the large majority are coarse, and not infrequently show graphic structure = graphic granite. The most common type is biotite-granite (quartz felspar biotite), but muscovite and hornblende are not infrequently present—a few of the specimens, indeed, might be correctly described as hornblende granite. Large phenocysts of orthoclase are often present, especially in the coarser granites. Some of the specimens show a rude banded structure, the rock having the appearance of gneiss-granite.

There were also specimens of pegmatite, a very coarsely crystalline aggregate of quartz-felspar and biotite or muscovite (one or both micas). It is probable that many of the specimens of quartz included in the collection are simply fragments of coarse pegmatite—flakes of mica and pieces of felspar being frequently adherent to the quartz. The inference, therefore, is that pegmatite is really more abundant in Lagos than the collection would seem to indicate.

There were also specimens of mica-schist, granulite, amphibolite, haplite, diorite, syenite, grit, pipe-clay, kaolin, and laterite.

The only minerals occurring separately in the collection are quartz and felspar. While much of the quartz is probably from veins, many of the specimens have apparently been derived from disintegrated pegmatite. The felspar is also probably of the same origin.

None of the stream-washings seems to call for any special reference. Unfortunately, none has yielded any trace of metals or ores of valuable metals.

From the geographical distribution of the rocks referred to in preceding paragraphs, it may be concluded that Lagos is

320 (*contd.*)

built up essentially of gneiss—this rock appearing to occur almost everywhere throughout the region. Associated with it in some places (as at Aro, Ibadan, Ondo, Jebu, &c.) are mica-schists. Probably this schist has a wider distribution than the collection would seem to indicate. It appears to be much decomposed, and it may thus often lie concealed under the product of its own decay. The relative absence of amphibolites is noteworthy. In keeping with this is the great development of granite and its varieties, and the rarity of diorite and syenite.

Put into few words, the geology of Lagos presents a complex of dominant granitoid gneiss, with important zones of quartzite, and subordinate developments of granulite and amphibolite. Piercing the gneisses, and, apparently, in some cases, passing into them are masses of granite, along with dykes and veins of haplite and pegmatite. The more basic plutonic rocks play an unimportant *rôle*—syenite appearing only in one place, while the diorites are of rare occurrence, and are hardly typical of their kind, most of them containing a high percentage of quartz. The whole "complex" is thus markedly acidic.

None of the rock-specimens gives any indication of the presence of valuable ores. Some of the finer-grained gneisses would probably make good building-stone; while the products of the decomposition of the richly felspathic rocks, if occurring in sufficient abundance, might be utilised, viz., kaolin (China clay) and pipe-clay.

The general character of the samples of stream-wash bears out that of the solid rocks—they are, apparently, devoid of any appreciable amount of valuable metal or metalliferous mineral.

(From a Report by Professor James Giekie.)

321. **Nigeria and Lagos.**—Between Abeokuta and Ilorin the prevailing rock is gneiss. (I., 3, C., 222.)

In North-west Bauchi, from the plains rise masses of irregular hills, composed entirely of granite, with large masses of felspar. The hill slopes are strewn with immense boulders. (I., 3, C., 233.)

To the west of Jebba, and north and north-west of Ilorin, are frequent outcrops of granite, and, near Jebba, quartz. (M.R. material, Nigeria/86.)

From above Garua to the point where the Benue River enters British territory, the valley has sandstone plateaux on the right. (D.K., 1903, p. 131.)

At Yellwa, on the Niger, are granite blocks. Above Bumba, on west of the Niger, are horizontal granitoids and rose-coloured sandstones. Above Yellogure are granite rocks.

(Lenfant: "Le Niger," Paris, 1903, pp. 148, 167, 171.)

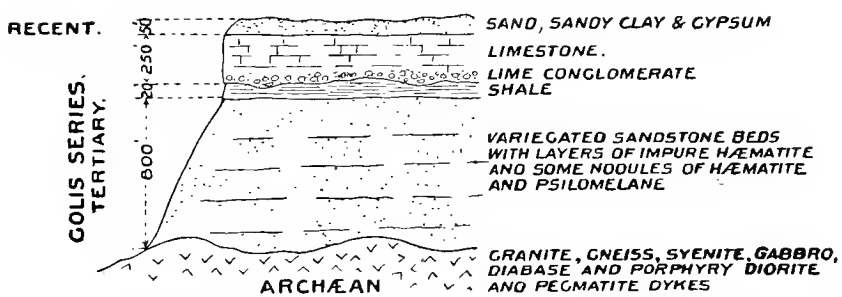
The most ancient formations will probably be found north-east of Old Calabar; some upheaving force seems to have affected portions of the delta, because, in places, land 20 feet or more above sea-level is found close to the

321 (*contd.*).

mouths of the rivers, although surrounded for miles inland by mangrove swamp (*e.g.*, Oron, at the mouth of the Cross River). Reports, which are as yet unauthenticated, tend to show that the country between Degema and Owerri may be found to possess characteristics inconsistent with a simple delta formation (*e.g.*, a ridge, said to be of rock, traverses the creek near Nsokpo).

(Acting High Commissioner Probyn.)

322. **British Somaliland.**—For geological consideration, British Somaliland may be divided into two sections, the dividing line being the great watershed which crosses the British-Abyssinian boundary nearly due south of Zeila, and trends eastward through Hargeisa, Upper Sheikh, and Negegr, approximately parallel to the Gulf of Aden coast line. This ridge or backbone of the country forms the northern boundary of Ogo, the great plateau of Somaliland, and also of that lime and sandstone formation which exists in most of the southern and by far the larger portion of British Somaliland. This series may be called the *Golis Series*, as it is in the steep cliffs of the northern slope of the Golis range that the different strata are best exposed. Lying nearly horizontally on top of Archæan granite, gneiss, and gabbro, the sandstone and limestone beds dip slightly in broad undulations to the south. The maximum dip is probably found at Upper Sheikh where it varies from 6 to 10 degrees. Comparatively recent deposits of gypsum and alluvium cover the Golis series in the vast plains to the south. An ideal section in descending order is shown below.



Recent.—At Aik, 43 miles south-west of Burao, several wells have been dug to a depth of 35 feet. The first few feet consist of a red calcareous sand carrying some small grains of magnetite. As depth is attained it becomes more of a clay, containing less silica and iron sand; 10 to 15 feet below the surface streaks of gypsum appear in the form of selenite, and this gypsum gradually increases in quantity until digging with a pick becomes slow and tedious. It is reported that further south in the Haud large deposits of much purer gypsum exist in the form of a compact rock.

322 (*contd.*).

At Burao, wells sunk at one side of the river bed to a depth of 60 feet show alternate layers of red sand and clay, as described above, gravel and boulders of rounded limestone. At neither Aik nor Burao was bedrock reached.

Golis Series.—The upper portion of this series consists of a bed of highly fossiliferous limestone. The numerous fossils collected by us have not yet been properly classified, but from them the age of the bed should be closely determined.* The bottom of this bed, immediately above the sandstone, is composed of a sandy limestone conglomerate carrying mostly fossil shells in which respect it differs from the top. The fossils of the upper or more compact portion of the bed are various marine remains, although many shells are also found. The maximum thickness of the limestone, as far as I have observed, is 250 feet. In other parts of the country it may exceed these figures. Many caves are formed by the weathering of the lime conglomerate just above the sandstone.

The sandstone upon which the limestone rests conformably is mostly of a yellow colour, but is alternated by red and white layers. In places the colouring is brilliant.

Nowhere have I seen the sandstone beds more than 800 feet in thickness, which, I think, is about the maximum. Certain light-coloured sandstone strata contain nodules of hydrated manganese oxide, psilomelane, but no workable deposits have been found. Some of the yellow and red strata contain nodules of limonite and red hæmatite, the latter often with a large percentage of manganese. At the foot of the sandstone bluffs I have picked up limonite pseudomorphs having the form of large pyrite crystals. The general structure of the sandstone is coarse grained and somewhat porous.

Archæan.—Where I have closely examined the Archæan rocks at Bun Yero, Sheikh, and Wager, along the northern edge of the great plateau, the following characteristics are noticeable :—

Near Bun Yero, about 20 miles west of Upper Sheikh, the Archæan rocks are mostly gneiss or a schistose granite. Many wide pegmatite dykes containing very large crystals of orthoclase and muscovite cut through the schists with a general north and south trend. The mica in many places furnishes sheets large enough to be of commercial value, particularly at Upper and Lower Ower Fur. Some diabase is seen, but the gnessoid rocks greatly predominate.

Going eastward to Upper Sheikh the pegmatite dykes are not so large. The muscovite is practically absent and more diabase appears. Porphyry dykes are common, running nearly east and west. The gneiss is largely replaced by unaltered granite and syenite.

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* Since pronounced to be Eocene.

322 (*contd.*).

Immediately east of Upper Sheikh is a large circular area, several miles in extent, over which very basic rocks occur carrying a great deal of magnetic iron in the form of small grains distributed through the mass, and sometimes in small lenses of pure magnetite. The principal rock is essentially a gabbro, but it is traversed by many diabase dykes, and in some places by syenite and pegmatites.

Towards Wager Mountain, 20 miles east of Sheikh, the basic rocks gradually disappear, Wager itself being mostly a flesh-coloured granite with small basic and pegmatite dykes. Some of the basic dykes are typical porphyry. On the top of Wager Mountain numerous quartz veins are found, in some cases 10 or 12 feet wide. They are very persistent, but none of them, however, were found to contain sulphides, and are probably barren as far as the precious metals are concerned.

Geology of the Guban.—North of the Somaliland watershed the formation is much broken by a series of faults through which the country has subsided in successive steps to the coast, eventually forming the Gulf of Aden. Along the coast a recent coral formation is found. Going inland from Berbera over a gradually rising plain of coral sand, small hills of coralline limestone are seen having a slight northern dip. About 9 miles from the shore is the Maritime range of mountains, the lower portion of which is variegated sandstone and conglomerates. These are overlaid conformably by limestones. The beds have a dip to the south of about 15 degrees. The formation bears a striking resemblance to the Golis series, but I had deferred a close examination until my return to the coast, so cannot say yet if they are the same age.

Fourteen miles south from Berbera hornblendic schists and granities are met with, intersected by pegmatite and diabase dykes. This Archæan formation is covered, 17 miles out, by the Bihendthola limestones which dip south at an angle of 20 degrees. These limestones, as well as those of the Maritime range, are said to be fossiliferous, and I hope to make a collection of fossils on my return. The recurrence of bedded formation would indicate faults north of the Maritime range and just north of Bihendthola. Another fault between Bihendthola and Gerlokhr (about 29 miles from Berbera) brings the Archæan rocks to the surface again. Here they are rather more acidic than they are near Bihendthola, more granite and less hornblendic schists.

The Owerado, outlying hills from the base of the plateau mountains, are isolated sections of the Golis series in the Guban, and indicate a great fault between them and Sheikh.

I have not, up to the present, been east or west of the Berbera-Sheikh line in the Guban, but from reports and judging from a distant view of the general topography, the same conditions maintain as are found on that line.

322 (*contd.*).

Basalt and recent volcanic rocks generally are reported as occurring along the extreme western boundary of British Somaliland, showing a line of eruption in a north-east and south-west direction. I hope to be able to examine this district in a very short time.

(From a preliminary report by Major R. G. Edwards Leckie.)

323. **Uganda Protectorate:** Sketch of the Geology of the Nyanza basin.—With regard to the theory of the course of the Nile before the Wadelai-Gondokoro plateau was breached by the river, with the present scanty information it is very premature to assume that the Nile and Lake Rudolph were once coupled by means of the valley of the Turkwell River.

There is strong reason to believe that this is a recently eroded valley, entirely formed since the elevation of Mount Elgon, in the crater of which the present river rises. I am inclined to believe that the outlet of the Nyanza basin to the north was probably by way of the Ruzi valley which joins the Sobat near Nasser.

Intimately connected with this question are the numerous evidences of the greater size of the lake in past ages.

There are beds of lake gravels in the Nyando valley many miles east of the present coast line of the lake, and traces of the old lake beaches are to be found; there is a series of caves high up on the Nandi escarpment; and again the north, south, and south-eastern sides of Elgon are riddled with water-worn caves up to an altitude of over 6,500 feet, or say quite 2,500 feet above the present level of the lake. (See Sections Nos. XV, XVII).

The caves shown in the above-mentioned section are over 2,000 feet above the present lake level, and this, and the height at which the Elgon caves are found gives us a measure of the amount of uplifting this part of the earth's surface has undergone.

Now consider the state of affairs before this took place, consider the terrain north of Elgon dropped 2,000 or even 1,000 feet, it will be seen that the Mau ridge will still be several thousand feet above the lake and form an effectual boundary on the east side, but on the north an estuary is opened right away to the Sahara sea or the Mediterranean with only the summits of Elgon, Dabasien, and the Latuka Mountains appearing as isolated islands. As the folding of the earth's crust, however, progressed, the lake basin became gradually cut off from the ocean, and was still further contracted in area as the Elgon mass was raised, and the Mau ridge and Nandi plateau assumed their present form.

Moore, by the presence of *Medusæ* in Tanganyika, professes to prove that that lake was formerly connected with the ocean; *Medusæ* have, however, recently been discovered in Lake Victoria, so that if argument has any value, this may be considered to support the above view of the question.

323 (*contd.*).

The majority of the Mollusca in the lake are I believe, of the ordinary fresh water types, *Unios*, &c. But I have seen an *Ostrea* found at Lusinga Island, which is said to bear great similarity to a marine form.

* * * * * * *

The foundation of the lake basin is primarily a primitive axis of granites, gneisses, &c., similar to the one which runs through from Abyssinia, east of Rudolph Lakes, and, with a break caused by the Kenia lavas, crops up again in Ukamba, and again at Teita and Ungweno; and this western core should, I think, be considered as the real back-bone of the Continent in preference to the Ukamba—Teita—Ungweno axis. It probably took on an anti-clinal fold at an early date, and has thus suffered longer from erosion, and is, consequently, generally speaking, not so prominent as the Ukamba—Teita axis. The general altitude of this axis, however, steadily increases as one goes eastward, and, although covered by a thick layer of volcanic rocks, is still responsible for the height of the Mau range. This is proved by the fact that primitive rocks are seen underlying the volcanic series in the enormous Elgeyo fault scarp. (See Section No. XV).

The Maragolia range may be taken as a type of one of the culminating points of this primitive axis.

In Eastern Kavirondo, in a minor fold of this axial ridge, there is a series of rocks, which were originally sedimentary, and consisted of shales, and occasionally bands of sandstone; these are now much contorted, broken up, and locally faulted, and although in some cases not greatly altered, in others have become truly schistose in character; as fossils have not been found in these rocks it is not easy to hazard a statement as to their age.

It is reported, however, that on the edge of the Kossova escarpment in about 1° 0″ S. lat. there are regularly stratified beds of sandstone and limestone practically untouched by metamorphic action; if this is so, they are probably part of the same series as those described above, and may turn out to contain direct palæontological evidence of their age. These beds are intersected in various places by numerous quartz reefs, some of which, in the vicinity of the Anglo-German frontier, are gold-bearing.

When the country is delineated accurately enough to admit of the construction of a geological map, it will, I believe, be found that this series of altered sedimentary rocks was originally spread over the primitive rocks in a more or less uniform manner throughout an enormous area, and, as the folding action took place, they disappeared from the anti-clines, and are now only to be seen in patches in minor synclines.

Certain patches of altered shales and grits, in Usoga, will, I think, be referred to this series, and probably the Ankole sedimentary deposits.

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Let us now leave this core of primitive rocks with its ancient sedimentary systems and turn our attention to the volcanic rocks.

The general theory of the Rift valley as a "Graben," or valley of subsidence, generally stands, but more information is required as to the origin of the colossal sheets of volcanic deposits which lie like a pall over the lofty Mau range, and, for example, along the line of the Uganda Railway, and stretch uninterruptedly from Molo down to Mohuroni, a distance of 65 miles—they are in constitution a complex mass of phonolites and ashes.

The enormous area over which these volcanic rocks extend leads one to suspect that there must have been many other foci of eruption than those of the Rift valley, but up to date I have only located one of any importance; this is a prominent mountain called Tinderet, which looms up in a striking manner some 8 miles to the north of Fort Ternan; the eastern wall of its crater is in fair preservation, and its summit is covered with magnificent juniper forest, the west side has been torn away during its final eruption, which must have been of extraordinary vehemence; as the lake at that time probably lapped the foot of the mountain, the infiltration of its water into the crater doubtless caused this eruption.

About 600 square miles of the country between the German frontier and the southern shores of Kavirondo Bay are also covered by recent volcanic rocks.

Extinct craters are legion, the more prominent being Homa Mountain, Ruri, Kasagunga, Gwasi, and Njerewe, Gwasi rising to a height of 7,500 feet above sea level. All these volcanoes are in close proximity to the shores of the lake, and inland there is a vast flat plain covered with a lava flow of very uniform character; probably some fissure eruption, occurring during periods of great volcanic activity, may have assisted in the distribution of this lava cap over such a vast area.

There are very interesting beds of volcanic ash and agglomerate to be seen in the Islands of Lusinga and Fangano, and, curiously enough, among the ashes are to be found large boulders of syenite and granite, the origin of which it is somewhat difficult to account for; but which suggest that these beds may be relics of eruptions of an older age rearranged by aqueous agency.

On Lusinga Island, too, there is a small limestone deposit interbedded with the volcanic ash. It does not appear to contain fossil remains, but, for all that, its microscopic examination may probably throw some light on its origin, and the point as to whether the lake was at one time connected with the ocean.

On the north side of the Kavirondo Gulf, from Kisumu as far as Uyoma Mountain, the primitive rocks are for the greater part of the distance covered by a narrow lava cap from 50 to 100 feet in thickness.

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At Kisumu itself they cover the plain, and are also lifted up to form the covering of the Kavirondo range by a fault running east and west. If these were derived from the centres of eruption at Homa, Ruri, &c., then the valley called Kavirondo Gulf must have been eroded by a big river since the period at which the Mohuroni gravels were deposited.

These rivers, the Kibos, Nyando, and Miriu or Sondo empty themselves into the head of the Gulf, but the Nyande is the only one possessing a valley of any magnitude, and now, rising at it does only some 80 miles from the lake, its present watershed cannot collect enough water to account for such extensive erosion; whether before the formation of the Rift valley and the final elevation of the Mau range it rose much farther east, it is very difficult to surmise; I am inclined to think that it might at one time have drained the area now occupied by the Rift valley.

Anyway, the fact remains that both the north and south sides of the Gulf are covered with a lava cap of very similar character, with a wide ridge between of gradually increasing depth as one proceeds westward.

A few words with regard to Elgon:—

This great mass is an extinct volcano 14,200 feet in height, and has geographically a very isolated position from the surrounding country, except on the east side, where it is connected with the Mau range by a lofty plateau covered with lava flows, the reason of this being that one of the last phases of its activity as a volcano was to breach its crater wall on the east side, and through this chasm enormous sheets of lava flooded the fertile plains, now known as the Guasangishu plateau. Geologically speaking, the great mass of the mountain is of much older date than the volcanoes of the Rift valley or Tinderet, previously referred to.

The lower part of the mountain is built in steps, gentle slopes alternating with cliffs, and this is due to this portion being composed of consecutive layers of ash and basic agglomerate. (See Section No. XVII).

The wave erosion round its flanks must have continued through an enormous period. At the foot of the first step, immediately at the base of the mountain, the primitive rocks, granites and gneisses, give way in a few yards to the agglomerates, which, in places, form huge cliffs some 600 to 700 feet in height.

Now, it is inconceivable that these agglomerates should, when erupted, have naturally ended off in these cliffs, but must, beyond doubt, have stretched far beyond their present point of termination, and been carved into cliffs by wave action, while the mountain was steadily rising.

At one time it was thought that these caves might be artificial, but I fear that this theory must be given up once and for for all, for they appear to me to be typical of wave

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erosion, the majority of them being wedge-shaped in section.

Unless we suppose a period of depression previous to the final elevation, we must fall back on the theory that the material of lower slopes of the mountain was deposited in water deep enough to reach up to the highest line of caves, which were excavated first by the wave action of this sea.

I have seen caves on the north, south, and south-eastern sides in each successive step up to about 7,500 feet. They may be found higher, but the dense forest is a bar to exhaustive search.

As far as is known, they are invariably found in the cliff faces of the hard agglomerates, the gentle slopes being the ash beds.

The recent lava flow on the east side has probably obliterated all traces of the caves on that side. At least I know of none in the area covered by this rock.

The natives on the mountain have a legend to the effect that their forefathers have handed down a story that fire once came out of the mountain and burnt up a large piece of the forest. As they have no experience of volcanoes this has an air of truth, and probably refers to some final flicker caused by the eruption of a small parasitic cone, but the mountain, generally speaking, ceased to erupt long before historic times.

In some of the ash beds large pieces of silicified wood are to be found, microscopic examination of which might give some clue to the age of the mountain.

I have on several occasions dug in the caves hoping to find relics of prehistoric human occupation, but nothing more than a few bones of domestic animals has rewarded my search.

A couple of feet of detritus weathered from the roof will be followed by a few inches of ashes, then another layer of natural débris and another layer of ashes, showing that the caves were inhabited for a time, and then deserted for a time, to be re-inhabited probably in a troublous era in the history of the tribe.

(Assistant-Deputy Commissioner C. W. Hobley.)

324. **Uganda Protectorate.**—On leaving Entebbe or following the main road to Hoima the formation is one of very recent volcanic action and one meets with nothing but igneous rocks which are strongly impregnated with iron.

The rocks remain in a more or less glassy condition in this country. But there are also large masses of holocrystalline rocks. There is no doubt that it is owing to the disintegration of older volcanic rocks that Uganda has such a wonderfully rich soil, probably some of the richest soil in the world, not even excepting some of the Pacific Islands.

Passing through Kigoma one notices a large body of olivine basalt that crosses the road at the Rest Camp. This rock

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carries large amounts of magnetite and titanic iron and in one place gave small patches of molybdenite. The whole country round is sown with fragments of glassy slag and also iron slag; one rarely finds these in large bulk and the edges are round and smooth, giving one a difficult question to solve, viz.: from whence all this scattered lava was ejected; for one does not find it except on the surface, and lying on rocks of an older period. The iron slag is mostly honey-combed, and is so rich in iron that on crushing the same in a mortar, the metal flattens out into small pellets. This is to be found anywhere between Lake Albert and Lake Victoria.

On coming to the valley of the Kafu River a few scattered rounded pebbles of blue quartz are found, which have evidently travelled some distance, and seem to be a likely looking stone for gold.

Nearly all the intrusive igneous rocks and traps run from the north-east to the south-west approximately.

On reaching the escarpments of Lake Albert, one finds a narrow belt of slates, mostly mica-schist, that vary from 2 to 4 miles in width. This is undoubtedly an auriferous belt that practically forms the southern escarpment to the Lake Albert—having a trend from the north-east to south-west. There are three reefs running parallel that one can trace up for miles. Diorite bars and trap dykes cut the formation in several places.

Following up this formation to the north-east to within one day of Fagao, where it tails out, it may be noted that the reef showing on the surface dips to the south-east and that the belt is flanked by a more recent volcanic upheaval to south-east and overlying the same.

On returning to Hoima a visit was made to the salt springs at Kibero, which is situated on the shore of Lake Albert. The natives at Kibero carry on quite a large trade with the salt. The escarpment of the lake over-looking the village has at one time been dotted with hot springs, that formerly flowed into the lake and have now become extinct. There is much evidence of pure sulphur and magnesian limestone, with layers of manganese diorite mixed with alumina soil.

The salt springs at Kibero rise close to the base of the mountain or escarpment. The water rises quite clear, and, at boiling point, gives off large quantities of sulphur fumes, that can be detected fully a mile away. The natives recover the salt by evaporating the water, for there is no deposit of salt. The water from the hot springs contains about 300 grains sodium chloride, 32 grains potassium chloride, 15 grains calcium sulphate, traces of magnesium sulphate, magnesium chloride and carbonate. Doubtless there must be a large deposit of salt to be found in the neighbourhood. The slate formation referred to above passes along the escarpment close to Kibero, to the south-west.

(*African Standard*, August 29, 1903.)

325. **East Africa Protectorate.**—Between Mombasa and Jombo shales of Jurassic age containing many fossils, chiefly ammonites, are to be seen almost the whole way. These shales also contain in great abundance ironstone nodules of varying composition. If an analysis of the nodules proved favourable, there would be here a valuable source of iron ore.

The rock of the escarpment of the Shimba Hills is a very coarse sandstone, split up by jointing into large rectangular blocks. The whole plateau is made up of this rock, and is in consequence a rather barren tract of country.

On the north side of Jombo Hill the rock, as far as can be determined from a microscopical examination, is a typical nepheline syenite, with basic modifications. No trace of gold occurs in the rock itself. The soil is of a deep red colour, and is exceedingly fertile.

Mrima Hill consists of a deep red earth, with blocks of vesicular lava and micaceous sandstone intermingled.

Sandstone is found all the way from Jombo to Tiwi, where the recent coral-sand formation is met with. The Jurassic shales are not developed.

The Taru Hills, 9 miles from Samburu, consist of coarse and fine sandstones containing felspar, black and white mica, graphite, and garnet, the two last minerals only developed in small quantity. These sandstones have evidently been derived from the metamorphosed rocks which occupy the great stretch of desert country to the west and north-west. Maungu Hill is composed entirely of gneiss with quartz felspar, and black mica developed. The last mineral often occurs in bands, so that the whole rock takes on a banded structure and may be described as a banded gneiss. Coarse veins with the same minerals—pegmatites—are very common, but no mineral of any value is found in them.

The Ndara and Ndi Hills, close to Voi, consist largely of the same gneiss rock very well bedded. The bedding planes have a constant dip almost due north, so that characteristic topographic forms are developed and the course of the river is also influenced.

Leaving Voi I camped close to the Voi River on the Taveta Road. For 2 miles or so on each side of the river a limestone with angular grains of quartz, &c., is found. This brecciated limestone is often found in patches in the gneiss rocks. I have since come to the conclusion that it does not form part of the gneiss rocks, but is much later in date. It may generally be found along the river courses. A coarsely crystalline limestone, with minute graphite scales developed, is also seen; this latter mineral occurs in too small a quantity to render the rock of any value. The limestone furnishes any lime that may be required in the district.

On the flanks of the Voi River the hills consist of highly metamorphosed rocks, such as mica gneiss, mica schist, and garnet mica cyanite schist, with coarsely crystalline limestone, which occur in regular succession.

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In the Mwatati Valley and beneath the peak of Makora, close to Wateita villages of Daruni Mulunguni and Goshi, similar rocks to those mentioned above occur. Water sinks through the gneiss rock and very often comes out as a spring along the bedding planes. An instance may be seen in the stream beneath Makora Peak and close to the villages. The same metamorphosed rocks make up the Mwatati and Bura Mountains.

Patches of limestone occur here and there between Bura and Taveta. Taveta itself is on volcanic rock. This dies out a mile or so east of Taveta, a patch of lava, however, being found 4 miles further east. The volcanic rocks consist of lavas and ashes, and may be well seen in the river. The lavas are basic rocks chiefly olivine basalts.

The hills south of Taveta all consist of gneiss rocks, garnet being plentifully developed. As examples, Mokinni, Gulunga, Kamalenza, and Keata Hills may be instanced. At Mokinni Hill, coarse pegmatetic veins are plentiful, but no other minerals occur in them besides quartz, felspar, garnet, mica, and magnetite. North of Taveta all the hills are of volcanic origin, such as Chalahakurta, Warombo, &c. The two types may be distinguished roughly near Taveta by the fact that the gneissic hills are forest-covered, whereas grass only occurs on the volcanic hills.

On the lower slopes of Kilimanjaro the typical specimens of the lavas consist of compact and vesicular black basalts with olivine.

I found no coal, and feel sure that none occurs in the district. Some reputed coal turned out to be merely charred wood. It is quite possible that the presence of a little black limestone on the road near the Voi River, and also of abundant black mica, with the appearance of fine coaldust, in the minute stream courses, has led people to infer that coal occurred in the Voi Taveta district.

The limestone is the only rock likely to be of any commercial value, and it is to be found only in patches.

I visited the Mtoto Andei district, and penetrated to the foot of the Kyulu Mountains. From the railway south-west along the river, almost to the railway reservoir, gneiss is the only rock developed. Coarse pegmatite veins, containing quartz, felspar, and magnetite, are not uncommonly found in it. Further south-west the gneiss is covered by basic vesicular lavas, which form plains, rising by steps to the foot of the Kyulu Mountains. These lavas are typical olivine basalts, the olivine being generally developed in large crystals. At the base of the hills the lavas are more fine-textured, and show excellent flow structure and ropy surfaces.

At many places along the river and its principal tributary, a reddish or yellowish-white conglomeratic limestone is

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met with. This consists of quartz and felspar grains, and occasionally garnet fragments, embedded in a matrix of calcium carbonate. The limestone contains no fossils, with perhaps the exception of *Succinea* (?). Blocks of gneiss and lava are often found inclosed, and the rock usually lies in horizontal or easterly dipping layers on highly-inclined gneiss and mica schist, dipping west or west-south-west. The limestone is obviously of later formation than the lava, and has without doubt been formed by the river itself. It is very well exposed in the excavations for the railway water-pipe; here it is purest and would afford the best lime.

There are thus in this district three quite different kinds of rock—gneiss, basic lava, and limestone—in close proximity to one another, so that it would be possible to make almost any desired kind of soil.

The rock of the Mbinzau Hills, and other hills to the north, is a pink granulitic gneiss, with many coarse pegmatetic veins, containing quartz, felspar, white mica, and either magnetite or ilmenite. I also examined the river deposits, and, as far as my investigations went, I should conclude that no alluvial gold occurs there. The deposits are either a blackish-grey carbonaceous mud, or grains of calcium carbonate in which small shells of a freshwater gasteropod are occasionally found. Limestone, similar to that of Mtoto Andei, occurs along the course of the river, filling up entirely old flood plains. Deposits of salt also occur close to the river. The Kemali and Kiu Hills are both of gneiss, with pegmatite veins containing the usual minerals. These hills rise out of a lava plain which stretches as far as mile 220. The Muani Hills, close to the railway, consist of olivine basalt, and a similar rock may be seen in horizontal beds in the river, whence it is continuous to the foot of the hills to the north-east. Proceeding over the pass towards Nzaui (Nzoi) Peak and the Ndange Valley, lava blocks are again seen half-way down the slope. A compact olivine basalt is exposed in a small stream close to the path, and probably marks the site of the volcanic vent from which the lava blocks were erupted and strewn around. The neighbouring hills all consist of gneiss. Nzani Peak also shows a compact gneiss dipping to the north-east, and this rock is continuous up the valley to Kilungu Peak.

The hill to the south of the Machakos Fort consists of a good biotite gneiss. A similar rock is developed all the way along the path to the Athi River, that at the Thwaki (Towaki) River containing numerous garnets. At Kibaoni Hill the dip of the gneiss is towards the west-south-west, and remains the same up to the Tiwa River. The north-west-south-east course of the Athi River is, to a great extent determined by this constant feature, for the direction of flow is generally along the strike of the beds.

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The hills of Dumoni, Ilimanuwi, and Mwavani and the Tiwa River take the same direction for the same reason.

The Kitui district consists entirely of gneiss. A cellular ironstone, produced by the decomposition of an iron-bearing gneiss, is seen on all the roads leading from the fort.

I proceeded to the Mumoni Mountains, passing by the Mtongoni Range and Nzaoni Hill. At a spot three hours' march from the pool at Kibui (three days from the fort) a small hill is seen to consist wholly of limestone. The purest rock is a white crystalline limestone, containing small blue crystals not unlike blue sapphires, but their octahedral form proves them to be a blue spinel. The next variety contains light brown flakes of phlogopite mica and yellow crystals of what is probably chondrodite. The most impure variety is a dark green rock containing abundant green pyroxene and quartz, and red garnet also come in. We have almost every gradation between a pure white limestone and a garnet pyroxene rock. Where the path enters the Pia River, a cliff of river-formed limestone is seen. The rock is impure, containing patches of milk opal and veins of quartz. The surrounding plain is also composed of the same rock.

The Mumoni Mountains consist of two parallel ranges separated by a tributary of the Thika Thika. The rock is gneiss, but a coarse pegmatite containing magnetite is exceedingly common. The octahedral crystals of magnetite are often $1\frac{1}{2}$ to 2 inches in width.

From the top of Zombeni, the peak of the easterly range, and at an altitude of about 4,300 feet, a great stretch of very diverse and peaky gneiss country may be seen. The pyramidal hill of Masikeakindu to the north-north-east, the peaks of Zungusu and Ngomeni to the east-south-east, Giani to the south-east, and Ithumbi to the south-south-east. To the south-west and south-south-west we have the big dome-shaped mass of Chaube and the more distant Kibwe Mountains, while to the west lies the Valley of the Tana. It seems exceedingly probable that all this gneiss country is quite barren as regards valuable minerals. I found nothing in the rock all the way from Maungu to the Mumoni Range. Here and there patches of limestone occur, those at Bura containing graphite scales, and the limestone hill on the Mumoni road with spinels and other minerals.

Between the Chano and Athi Rivers occurs a great plateau composed entirely of lava. On the Kitui road the lava is from 3 to 4 miles wide, and its average thickness is 30 or 40 feet. I followed it for 25 miles to the south-east down the left bank of the river, and it probably extends beyond Yatta Hill, near Kibwezi. To the north-west it appears to be continuous round the bend of the Athi with the lavas of the Nairobi district. To the north-west it

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occasionally increases greatly in thickness, so that in all probability it was poured out on an uneven surface of gneiss. In composition and texture it is remarkably constant over long distances, being characterised by long well-shaped felspars, and either hexagonal or rounded crystals of eleolite (nepheline) in a greyish-black ground mass.

Longonot is an old volcanic vent. The mountain consists chiefly of a very fine ash; blocks of atrachytic lava are very common; these are usually vesicular, and have a glassy exterior, in which large clear sanidine felspars are conspicuous.

Between Nakuru and Eldoma Ravine, along the Uganda road, volcanic breccia and fine ash are met with almost the whole way. Crystals of sanidine felspar and fragments of the acid lava-obsidian occur plentifully. Larger blocks of obsidian with porphyritic felspars and a dark compact, fine-grained lava are also seen. The latter becomes more common nearer the ravine, and alternates with the ash and breccia. The hill on which the station stands is formed of a similar compact lava, very liable to decay, producing a greenish white or pure white kaolin-like rock.

For the first 10 or 15 miles of the road, from Eldoma towards Baringo, lava, breccia, and fine ash are all represented. In the bed of a small stream two hours' march from the River Tigrish some very hard compact breccias are seen. These have the streaky appearance which is very characteristic of a similar class of rocks found in Cumberland and Westmoreland. The rocks were originally loose fragmental deposits, which have since become compacted by the infiltration of heated waters—silicification and chlorilisation having taken place; iron pyrites has also been introduced. This process of solfataric action must have gone on almost contemporaneously with the formation of the beds, for blocks of the flinty rock are found in the partially compacted breccias above. Irregular polygonal jointing is well shown here; the polygonal areas of rock are sometimes separated by cracks, but generally the cracks have been infilled either with quartz, red jasper, or with ironstone. This kind of jointing is characteristic of the Kamasia and Likipia rocks.

From the stream to the River Tigrish, the path crosses an extensive lava plateau. The lava varies in texture, but lath-shaped porphyritic felspars are usually developed. Dropping down to the level of the river we again come to fine ash and breccia, very well seen in section in a bend of the river. Opals and agates occur in abundance on the west side of the river, but there was not one good opal among those collected. The rocks on the west side of the river are chiefly lavas. Close to the river a fine basalt occurs covered by a mass of streaky breccia. Further west, towards the scarp, we get compact and vesicular

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lavas, all containing long porphyritic felspars. The coarse-textured lavas approach very nearly anepheline syenite.

Stretching eastward from the river is an extensive lava plateau, over which the path runs. The lava is probably of no great thickness, for, in the stream valleys, a breccia is found underneath. Lavas of varying texture and composition persist almost to the Molo River. Here the low cliffs jutting into the sandy lake deposits are all coarse breccias.

On the path at the base of the Likipia scarp, among the thorn scrub, blocks of cellular limestone may be seen associated with scattered blocks of lava. The limestone is doubtless of lake formation. Not having followed the shore of the lake, I do not know whether a similar limestone is found elsewhere; its occurrence here may be accounted for by the fact that the rocks on the scarp just above are exceedingly rich in calcite.

The Likipia escarpment at this point may be considered to consist of a thick lower scarp of lava—a roughly level plain of coarse breccia, on which the hill boma stands, and a second steep lava scarp.

The lower lava is chiefly a very basic augite porphyrite, occasionally containing lath-shaped felspars. When decomposed, it forms a purplish mass, plentifully veined with calcite, doubtless derived from the rock itself.

The plain on which the boma stands is plentifully strewn with lava blocks. It is interrupted to the north by high ground, among which stands an isolated peak, having a basic rock below and a phonolite above. These Likipia lavas show a great tendency to spheroidal weathering, and the ground is often covered with the ball-shaped kernels of the spheroids. North of the peak stretches a great plain, in which the River Mogodeni runs. In some of the dry stream courses of the plain, excellent sections of a coarse breccia are seen, containing huge blocks of lava, similar to that found above and below.

The upper scarp of Likipia consists almost entirely of lava; occasionally, on the top of the successive steps, vesicular modifications are seen. The base of the scarp consists chiefly of compact fine-grained phonolitic rocks, showing beautiful flow structure. These lavas are continuous over long distances, and form a horizontal line of wooded cliffs on the face of the scarp.

The Molo River runs in a deep gorge for the greater part of its course, flanked on the east by a prominent scarp of compact and vesicular lavas. Breccias are rarely seen. Further north, typical vesicular lavas crop out, and then sanidine and obsidian-bearing ashes occur continuously to the Uganda road.

Eldalat is a good example of a volcanic cone, but is interesting in the fact that it is dissected by a stream running east and west, which has cut a ravine in the east flank of the cone almost down to its base.

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Menengai Hill itself, and the surrounding country, consist of a coarse sanidine-bearing ash. Similar ashes, as mentioned above, are found along the Uganda road, and also round Nakuru Lake. Menengai was obviously the cone from which all this fragmental material was thrown out.

Coarse breccias persist until Lake Hannington is reached. Here an excellent lava, with porphyritic felspars, occurs on the fault scarp to the west of the lake plain. The fact of depression in the neighbourhood of the lake is well shown by the lava beds at the top of the Likipia scarp. They are seen to dip north at a small angle, whereas usually they are horizontal.

From the lake to the river in the north, nothing but fine ash occurs. The river takes its rise on Likipia, flowing west and north-west. It then enters a steep-sided and thickly-wooded gorge, turning north, and finally north-west, emerging on to the Njempsian plain. Along its course are the same types of lava met with further north, basic augite porphyrites being especially common. In the dry stream beds the loose blocks and pebbles are seen to be coated, and often cemented together, with a deposit of carbonate of lime. This phenomenon is very common in the gneiss country, round Makindu and Mtoto Andei, but I had not hitherto seen it among the lavas. The limestone is derived from the rocks, and is never in great quantity.

Practically the whole scarp of the Kamasia Range is of lava formation, and the lava is very constant in composition. These massive lavas are well seen in a dry ravine cut by a tributary of the Tigrish River at the point where the Tigrish leaves its gorge and emerges on to the Njemps plain; a massive lava over 100 feet thick is seen lying on a bed of ash, which it has indurated and burnt to the depth of 5 inches, the resulting rock greatly resembling glassy obsidian.

On the summit of Kamasia the lava becomes porphyritic, nepheline being developed in rounded crystals.

The Ndo valley, separating Kamasia and Elgeyo, is mostly formed of alluvium, derived from the adjoining slopes.

The Elgeyo scarp consists, at its base, of rocks of the gneissic series, quartz, felspar rocks, and above, garnet granulites and eclogites; a porphyritic phonolite lava caps this gneissic series, but is irregularly distributed over it. Patches of lava occur below the level of the gneiss rocks, thus proving that the lava was poured out over a very uneven surface. This thin strip of gneiss probably runs for some distance along the base of the scarp.

From the ridge a great grass plain extends westwards for miles, consisting entirely of lava. Occasionally, along the river, patches of a banded garnet gneiss appear, giving evidence of an approach to the limit of the lava, which finally ceases a few miles to the east of the River Nollosegelli.

From here to Mumia's the rock is all a granite gneiss of the simplest composition: Yekupe is a typical example of a granite hill. The same rock persists throughout the Surangai Hills, where veins of a fine-grained granite or even of a garnet granulite are found in it.

The rocky ridge to the south-east of the Nzoia River in Ketosh consists also of granite, but augite occurs instead of brolite, and a brown mineral, possibly axinite, comes in as an accessory mineral. Across the river we have the typical granite knolls of Sangalo.

The station at Mumia's is situated on lava which occurs in patches in the surrounding neighbourhood.

From Mumia's to Samia, travelling down the south-east bank of the Nzoia, is typical granite country as far as Legos. Here a curious compact and highly flinty breccia becomes prominent. It is probably of volcanic origin.

The Wanyara Hills consist of beautifully banded ironstone halleflinta. This iron ore often occurs in thick seams. The whole of the Samia district is exceeding rich in iron, but there is very little wood.

Here it is easy to see the mode of formation of the ironstone breccia so common in North and South Kavirondo, forming often a large flat surface over considerable stretches of country.

Water percolating through iron-bearing rocks carries away some of the iron in solution. It runs through the detritus of loose stones on the slope or at the foot of the hill, and, becoming evaporated, deposits the iron among the rubble. This in time becomes a hard cemented mass.

I returned to Mumia's through the Washeshi Hills to the Uganda road. Granite again occurs some 15 miles from the river.

Small patches of lava occur along the road from Mumia's to Kisumu, *viâ* Kakamega, Tiriki, and Maragoli. Compact flinty rocks are found in the Sioko River, near the American Mission Station: the gneissic series is represented by outcrops of true slate and a coarse felspathic sandstone; towards Nandi, however, a porphyritic granite is seen. This persists throughout the Maragoli Hills. Before the Kisumu plain is reached a small lava plateau is crossed; the lava is a nepheline rock, sometimes showing good flow structure. The plateau is not continuous, the granite occasionally jutting through; it may, however, be traced as far as the Semia district to the west, and up to the Kebosh River on the east.

(E. E. Walker, "Reports on the Geology of the East Africa Protectorate." Cd. 1769. Africa No. 11, 1903).

326. **East Africa Protectorate.**—Mount Sheba, on the Gwaso Nyiro, is a gneiss mass, and all the surrounding country is strewn with huge blocks of lava.

North of the Gwaso Nyiro, reaching to the East Rendili

country, the plains are strewn with lava, the dry water-courses and ridges being covered with broken quartz and boulders of gneiss. The Haldaiyan hills are volcanic. (I., 3, C., 315.)

327. **East Africa Protectorate.**—A large part of the East Africa Protectorate is covered by a cap of lava and volcanic rock. This probably does not extend over the northern portions. Iron occurs in abundance in most districts. Mica and graphite are found in Ukamba, the former in a considerable belt. Limestone has been discovered in several places, particularly near Kitui and Lake Victoria. In the southern part of Ukamba, near the German frontier, is a large deposit of carbonate of soda. Fine marble has been found north of Mount Elgon. (Cd. 1626, 1903.)

From Lake Natron northwards, past Lake Naivasha, to the south end of Lake Rudolf, the whole area is lava, except a few mountains of schist.

(M.R. material, British East Africa/92.)

328. **British Central Africa.**—Specimens from British Central Africa show that this portion of Africa and "Peninsular" India are geologically of the same structure, having in pre-Tertiary times formed one Continent. The specimens may be grouped as follows :—

1. Granitoid gneiss.
2. Upper group of complex schists and gneisses containing limestones and iron ores.
3. Transition, azoic shales, and sandstones.
4. Intrusive gabbro and decomposed peridotites.
5. Gondwana rocks.
6. Trap-flows and diabase (dolerite) dykes.

(Dunstan and Holland: *British Central Africa Gazette*, 1903, No. 3, p. 46, No. 4, p. 61.)

329. **North-eastern Rhodesia.**—A gold-bearing deposit is being developed at Sasare, about 90 miles west of Fort Jameson. It consists of two quartz reefs, striking about east and west, and lying between beds of crystalline schists. These reefs, which vary very much in width, and in many places carry visible gold, have been proved to a depth of nearly 300 feet. Near the same spot there has been recently discovered an extensive reef of copper ore, carrying both gold and silver.

Mining operations are being carried on at Kansanshi, at the head-waters of the Kafue, and also at Kambove, in Congo territory. Copper and lead deposits have been discovered near the Kafue, and also between the Loangwa and Kafue. At Broken Hill the ore consists of carbonate of lead, and of galena, the latter carrying silver. Two low kopjes, both practically masses of ore, are being worked.

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EXPLANATION OF THE TERMS AND GLOSSARY.

The terms used in Great Britain and on the Continent for the various divisions of the Tertiary age are practically identical, and those for the Palæozoic age differ but little. The following table shows the order in which the chief sub-divisions of the Secondary or Mesozoic appear:— Encyclopedia Britannica.

Britain.			Continent.
Cretaceous		Upper ...	Senonian—*Craie blanche et tuffeau, Upper Quadersandstein*
			Turonian—Plänerkalk
			Cenomanian—Grès vert Gault
		Lower ...	Neocomian
Jurassic	Oolitic...	Upper ...	Upper or White Jura (Malm)
		Lower ...	Middle or Brown Jura (Dogger)
	Liassic...	... ...	Lower or Black Jura (Lias)
Triassic		Upper ...	Rhætic beds, Keuper
			Muschelkalk
		Lower ...	Bunter

The terms employed in describing igneous rocks are given in the following simple form by Mennell:— Mennell, Geolog. Mag., August, 1902.

	Eruptive (= Lava Flows).	Intrusive (= Dyke Rocks).	Plutonic (= Rock Consolidated at Great Depths).
Acid*	Rhyolite	Granophyre† ...	Granite
Sub-acid	Trachyte	Felsophyre‡ ...	Syenite
Sub-basic	Andesite	Porphyrite ...	Diorite
Basic§	Basalt	Dolerite	Gabbro

* In the Acid group the percentage of silica ranges from 60 to 75 per cent.

† Quartz-felsite. ‡ Sometimes called felsite.

§ In the Basic group the percentage of silica is only about 50 per cent.

GLOSSARY.

Acid, *see* Quartz.

Agglomerate is the term used for any heterogeneous admixture of igneous fragments consolidated into a rocky mass, *c.f.* Conglomerate.

Amphibolite is a term used by some for hornblende rock (*q.v.*), and by others for diabase (*q.v.*).

Amygdaloid is a soft, earthy variety of trap rock.

Andesite is a triclinic mineral (*see* Felspar) consisting of plagioclase and hornblende or augite, and is often, if not always, altered oligoclase.

Archæan is the term applied to the masses of gneiss and other crystalline schistose rocks belonging probably to widely different geological periods, and underlying the unaltered stratified formations which themselves are derived partly from them.

Augite is of practically the same composition as hornblende, but the crystals are generally more stumpy. It is common in basic crystalline rocks and is not often associated with quartz.

Axinite is a triclinic mineral with glassy lustre and varying colour, clove brown, plain blue and pearl-grey, according to the direction in which it is viewed. It is composed of silica, alumina, lime and sesquioxides of iron and manganese.

Bajocian corresponds with the lower oolite, and holds a position immediately below the Cornbrash of the Bathonian series.

Basalt is a close-grained, black, heavy, volcanic rock, consisting of triclinic felspar, augite, olivine, magnetic iron, with apatite and sometimes sanidine.

Basic, *see* Quartz.

Biotite is a black, basic, magnesium mica, which was formerly called magnesia mica.

Breccia is a coarse rock made of sharp-edged or angular pieces of stone, which have been simply broken from some other rock and cemented together by a paste of fine mud or sand, or by a deposit of carbonate of lime or some other chemical substance.

Cenomanian corresponds with the upper greensand.

Chert is an impure flint, containing more clay or lime than silica, and occurs in concretions, nodules and rock masses.

Chlorite schist is a schistose aggregate of green chlorite, often combined with quartz, felspar, mica or talc.

Clay-slate is a compact, close-grained, very hard fissile argillaceous rock.

Conglomerate is the name applied to any rock which is formed of consolidated shingle or gravel, *c.f.* Agglomerate.

Danian corresponds with the upper chalk.

Diabase is a term applied to certain dark green or almost black eruptive rocks usually associated with the older formations; it is a fine-grained compound of hornblende and labradorite (a plagioclase mineral).

Diallage is a non-aluminous variety of pyroxene, of greyish green or grass-green colour, and is common especially in serpentine rocks.

Diorite, sometimes called Greenstone, is a crystalline mixture of oligoclase and hornblende with magnetic iron.

Dolerite is a coarsely crystalline variety of basalt.

Dolomite is a massive formation, from dull granular to finely crystalline in texture, of the carbonates of lime and magnesia usually associated with gypsum, rock salt, &c. This is sometimes called magnesian limestone.

Felsite is composed of orthoclase and quartz so mixed that the eye cannot distinguish them.

Felspar is a mineral composed chiefly of silica, alumina and potash or soda, and has a straight, glassy cleavage. The felspars are grouped into two series, the monoclinic or orthoclase, with a preponderance of silica, and the triclinic or plagioclase.

Gabbro, or Diallage rock, is a coarsely crystalline compound of a triclinic felspar and diallage, often with olivine. (*See* table on p. 114.)

Garnet is a red or green composite silicate of lime, alumina, iron, &c.

Gault is the lowest or clay series of the upper Cretaceous group.

Gneiss is a crystalline schistose aggregate of the same materials as granite, namely, quartz, felspar and mica.

Granite is a thoroughly crystalline mixture of quartz, felspar and mica.

Granulite is made up of irregular crystalline grains (not complete crystals) of approximately even size interlocking together, and is produced generally from gneiss-rocks by regional metamorphism. It is sometimes called Semi-granite.

Graphite is carbon, either pure or with a slight admixture of iron or occasionally silica, alumina and lime. It has a metallic silvery lustre and varies from iron-black to steel-grey in colour. It is met with in the metamorphic rocks and is probably metamorphosed coal. It is commonly called Black-lead. It is usually found in compact laminated masses, but sometimes crystallized in six-sided plates.

Greenstone, *see* Diorite.

Greywacke is a compact aggregate of rounded or sub-angular grains of quartz, slate, felspar or other minerals or rocks cemented by a matrix which may be argillaceous, felspathic or calcareous, but is usually siliceous. This term was originally applied to all pre-Devonian rocks.

Gypsum is sulphate of lime, and occurs either massive, granular or fibrous; when crystallised it is known as selenite.

Hæmatite is peroxide of iron, and is found crystallised in veins through crystalline rocks, and also occurs massive and earthy in beds.

Halleflinta is a compact flinty quartz rock ribboned with hæmatite bands.

Haplite is a crystalline-granular admixture of felspar and quartz, sometimes called Semi-granite. Graphic-granite, called also Pegmatite, is a variety.

Hornblende is a dark green or black mineral, with horny, glistening fracture, and is found in granites and greenstones. It is a normal silicate of lime, iron and magnesia.

Kaolin, or China-clay, is hydrated silicate of alumina formed from the disintegration of the felspar of granites, &c.

Killas is a clay-slate in which the ores of copper and tin are found in Cornwall. It is a coarse, argillaceous schist, with granite veins, which, at the junction, convert it into hornblende schist.

Laterite is defined by Lyell as a red, jaspery rock compound of silicate of alumina and iron. Rutley defines it as a red, earthy rock occurring between basalt and other lava flows, and resulting from their decomposition. It is, he says, strongly impregnated with sesquioxide of iron, and sometimes also contains hæmatite and beauxite. It should be noticed that in these notes the authorities, in some cases, appear to use the term loosely for any old rock decomposed and impregnated with iron.

Leptynite, or Granulite, is a crystalline schistose aggregate of orthoclase and quartz.

Limonite is a yellow or red oxide of iron combined with water, having a more or less fibrous structure; more frequently earthy; it often forms the colouring matter of rocks. It includes bog-ore, and some clay-ironstones.

Liparite, Rhyolite or Quartz Trachyte, is an orthoclase rock, with an excess of silica, the latter in distinct grains.

Madrepore is a term applied loosely to any coral distinguished by superficial star-shaped cavities.

Magnesian limestone, *see* Dolomite.

Magnetite, which is an oxide of iron, appears in minute grains through crystalline rocks. In basalt it is a chief constituent. It also occurs in veins and beds in many metamorphic rocks.

Marl is a term loosely applied to all friable compounds of lime and clay.

Melaphyre is a petrological group of species akin both to basalt and

diabase, and quite indistinguishable in external appearance from the former, but, as a rule, not so heavy, dark or compact, and does not contain so much olivine.

Mica is a soft, sectile, glistening mineral, which readily splits into thin, transparent plates, and is composed mainly of silica, potash and magnesia.

Mica schist is a schistose aggregate of quartz and mica.

Molybdenite is a soft mineral occurring mostly in foliated masses or as aggregates of minute scales. It has a metallic lustre, and is lead-grey in colour, and is found distributed among the crystalline rocks. In composition it is sulphide of molybdenum.

Muscovite is a white mica composed of silicate of alumina with potash, not infrequently met with coloured by impurities.

Neocomian corresponds with the Weald clay and Hastings beds.

Obsidian is a volcanic glass, resembling bottle glass, which breaks into sharp splinters, semi-transparent or translucent at the edges.

Olivine is a basic silicate of magnesia with some iron, crystallizing on the trimetric system; it has no cleavage and a glassy lustre. At first sight it looks very much like quartz, but is distinguished by its beautiful olive-green colour and hardness.

Orthoclase rocks are those which have orthoclase (*see* under Felspar) as their chief silicate, and correspond generally with the acid group.

Pegmatite is a very coarsely grained aggregate of quartz, felspar and biotite or muscovite. By some geologists all coarsely grained granites are called Pegmatite.

Phonolite, or Clinkstone, is a volcanic rock of late geological date, and is frequently found filling volcanic orifices, sometimes as sheets. It consists of a mixture of sanidine felspar and nepteline with hornblende.

Phyllite is a term applied both to a mineral occurring in small, shiny scales in clay-slate, and to some slaty rocks apparently intermediate between mica schist and ordinary clay-slate.

Plagioclase rocks are those in which the chief silicate is some species of triclinic felspar (*q.v.*), and corresponds with the basic group.

Porphyry is a term originally applied to a rock having a purple-coloured base, with enclosed individual crystals of a felspar, and is still used by some as a generic name for all rocks consisting of a felsitic base, with felspar crystals. Most English writers now, however, use it only in its adjectival form, and apply it to any rock in which crystals of felspar are individually developed, irrespective of the mineralogical composition of the whole.

Potstone is a sectile steatite (*q.v.*) rock with great power of resisting heat.

Psylomelane is hydrated manganese oxide.

Puddingstone, *see* Conglomerate.

Pyroxene is a name used for a group of minerals of very variable composition and origin, consisting generally of a large percentage of lime, with magnesia, the protoxides of iron and manganese, and sometimes soda and potash. The crystals are monoclinic with conchoidal fracture. The colour varies greatly, including shades of green, and from white to black. The lighter are found in metamorphic rocks, the darker in eruptive. The variety characterising serpentine and gabbro is Diallage (*q.v.*).

Quartz is pure silica, and forms the basis of the division of igneous rocks into *acid*, containing from 60 to 75 per cent. of silica, and *basic* with only 50 per cent.

Quartzite, *see* Quartz rock.

Quartz rock (Quartzite) is a close-grained, granular aggregate of quartz, cemented by a highly silicious matrix.

Rhyolite, *see* Liparite.

Sanidine is a very pure variety of Orthoclase (*q.v.*) occurring in clear glassy crystals of a tabular habit in certain volcanic rocks.

Selenite, *see* Gypsum.

Senonian corresponds with the upper and lower chalk.

Serpentine is a hydrated silicate of magnesia, usually amorphous, and green, yellow or red, formed from the decomposition of ordinary silicates, and common in crystalline rocks, especially the more ancient ones.

Shale is a clay-rock of thinly stratified or fissile structure, in consequence of the clay having been deposited intermittently.

Steatite is a species of talc, with a greasy or soapy feel.

Syenite is a mixture of orthoclase and hornblende, sometimes with quartz, mica or plagioclase. Formerly this term was used for a granite in which hornblende took the place of mica.

Talc is a whitish-green magnesian mineral, resembling mica. It is transparent when in thin plates, but is generally massive, sectile, soft and non-elastic.

Talc schist is a schistose aggregate of whitish-green or yellowish talc, often combined with felspar or quartz.

Tithonian is a term applied to a series of rocks occurring between the Neocomian and the Oolite, and probably of the same age as a part of the Wealden series.

Trachyte is a modern rough volcanic rock consisting of sanidine with triclinic felspar, hornblende, &c.

Trap is a term which includes a great variety of igneous rocks, such as basalt, greenstone, &c., which give a peculiar step-like (trappa, a stair) appearance to the hills composed of them.

Travertine (Calcareous tufa) is the material deposited by calcareous springs.

Tuff is a term used to include all the finer kinds of volcanic detritus, and is sub-divided, according to the nature of the lava of which it is a derivative, into felsite-tuff, trachyte-tuff, &c.

Turonian beds, which consist of chalk marl and chlorate marl, hold a position between the Greensand and the Lower chalk.

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